PNL--7367

DE91 005300

INHALATION DEVELOPMENTAL TOXICOLOGY STUDIES: GALLIUM ARSENIDE IN MICE AND RATS

Final Report
Contract No. NIH-Y01-ES-70153

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December 1990

Prepared for the
National Institute of Environmental
Health Sciences, National Toxicology
Program under a Related Services Agreement
with the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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SUMMARY

Gallium arsenide is a crystalline compound used extensively in the semiconductor industry. Workers preparing solar cells and gallium arsenide ingots and wafers are potentially at risk from the inhalation of gallium arsenide dust. The potential for gallium arsenide to cause developmental toxicity was assessed in Sprague-Dawley rats and CD-1 (Swiss) mice exposed to 0, 10, 37, or 75 mg/m^3 gallium arsenide, 6 h/day, 7 days/week. Each of the four treatment groups consisted of 10 virgin females (for comparison), and ≈30 positively mated rats or ≈24 positively mated mice. Mice were exposed on 4-17 days of gestation (dg), and rats on 4-19 dg. The day of plug or sperm detection was designated as 0 dg. Body weights were obtained throughout the study period, and uterine and fetal body weights were obtained at sacrifice (rats, 20 dg; mice, 18 dg). Implants were enumerated and their status recorded. Live fetuses were sexed and examined for gross, visceral, skeletal, and soft-tissue craniofacial defects. Gallium and arsenic concentrations were determined in the maternal blood and uterine contents of the rats (3/group) at 7, 14, and 20 dg.

Pregnant and virgin rats exhibited signs of pulmonary toxicity (dyspnea and grey, mottled lungs); however, there were no effects on maternal body weight. Developmental toxicity in the form of concentration-related growth retardation, evidenced as reduced fetal body weight and an increased incidence of skeletal variations became statistically significant at 37 mg/m^3. There was no evidence of embryotoxicity or frank teratogenicity. The maternal NOAEL for inhaled gallium arsenide in rats is at least 10-mg/m^3. The NOAEL for developmental toxicity is 10 mg/m^3 if determined solely on the basis of adverse effects achieving statistical significance; however, nonsignificant indications of developmental toxicity were present at this exposure concentration.

Determination of gallium and arsenic concentrations in maternal rat blood and in the conceptus showed that arsenic concentration in the blood achieved high levels (170 µg/g at 75 mg/m^3 on 20 dg), increased with exposure concentration, and over the course of exposures. Arsenic concentrations in

the developing fetus were elevated above controls in a concentration-related fashion (2.2 µg/g at 75 mg/m^3 on 20 dg), but were far exceeded by maternal blood concentrations. The excess arsenic in the maternal blood was probably tightly bound to hemoglobin in the erythrocytes, and thus was not available for placental transfer. Gallium concentrations were much lower than arsenic levels in both the maternal blood and in the conceptus, but gallium concentration was greater in the fetus than in the dam (approximately 1.3 vs. 0.5 µg/g at 75 mg/m^3 on 20 dg, respectively).

Swiss (CD-1) mice were much more sensitive to the effects of gallium arsenide than were the rats. The two highest exposure concentrations were maternally lethal to some animals; body weights and body weight gains were reduced in survivors of both of these groups. Mice in the 37 and 75 mg/m^3 groups exhibited signs of pulmonary toxicity; minimal pulmonary toxicity was observed in the 10-mg/m^3 group. A NOAEL for maternal toxicity in mice was not achieved in this study. Developmental toxicity was evident in all three exposed groups, and became statistically significant at the 37-mg/m^3 exposure concentration. There were signs of embryolethality, fetal growth retardation, significant increases in the incidence of fetal variations (primarily sternebral defects), and a slight, but not statistically significant, increase in the incidence of fetal malformations. A NOAEL for developmental toxicity was not achieved in this study.

TABLE I. Gallium Arsenide Inhalation Developmental Toxicity Study: Summary of Results for Sprague-Lawley Rats.

Target Gallium Arsenide Conc. [mg/m^3]	Mortality[a] [page 29]	Final Body Weight[b] (Mean[g]±SD) (% Difference from Controls) [page 30]	Gross Observations[a] (Incidence) [page 29]	Live Fetuses per Litter (Mean±SD) (% Difference from Controls) [page 30]	Fetal Weight (Mean±SD) (% Difference from Controls) [page 30]	Significant Fetal Variations and Malformations [page 30]
0	0/30	420.9 ± 35.4		14.7 ± 3.5	3.70 ± 0.24 (M) 3.57 ± 0.27 (F)	
10	0/31	419.8 ± 39.5 (-0.3)	Lungs, mottled (1/31) Lungs, red and mottled (24/31) Lungs, grey and mottled (2/31)	15.0 ± 3.5 (+2.0)	3.59 ± 0.23 (M) (-3.0) 3.42 ± 0.24 (F) (-3.4)	NS
37	0/30	427.1 ± 26.9 (+1.5)	Lungs, red and mottled (4/30) Lungs, grey and mottled (27/30)	14.9 ± 2.4 (+1.4)	3.56 ± 0.21 (M) (-3.8) 3.39 ± 0.18 (F)* (-5.0)	Reduced Ossification Sternebrae ↑
75	0/30	419.5 ± 33.0 (-0.3)	Lungs, red and mottled (2/30) Lungs, grey and mottled (28/30)	14.4 ± 5.1 (-2.0)	3.34 ± 0.32 (M)* (-9.7) 3.20 ± 0.30 (F)* (-10.4)	Reduced Ossification Sternebrae ↑

[a] Includes all sperm positive females.
[b] Includes only pregnant females.
* $p<0.05$.
NS = not toxicologically significant.

TABLE II. Gallium Arsenide Inhalation Developmental Toxicity Study: Summary of Results for Female CD-1 (Swiss) Mice.

Target Gallium Arsenide Conc. [mg/m^3]	Mortality[a] [page 31]	Final Body Weight[b] (Mean[g]±SD) (% Difference from Controls) [page 31]	Gross Observations[c] (Incidence) [page 31]	Live Fetuses per Litter (Mean±SD) (% Difference from Controls) [page 32]	Fetal Weight (Mean±SD) (% Difference from Controls) [page 33]	Significant Fetal Variations and Malformations (Incidence) [page 33]
0	0/23	54.8 ± 5.8	Lungs, grey and mottled (1/23)	11.9 ± 3.0	1.34 ± 0.09 (M) 1.33 ± 0.10 (F)	
10	0/24	52.9 ± 8.8 (-3.5)	Lungs, mottled (3/24) Lungs, grey and mottled (2/24) Liver, lesion (1/24)	11.0 ± 4.1 (-7.6)	1.27 ± 0.11 (M) (-5.2) 1.25 ± 0.11 (F) (-6.0)	NS
37	5/22	47.2 ± 10.4 (-13.9)	Lungs, grey (1/17) Lungs, mottled (1/17) Lungs, grey and mottled (16/17) Liver, lesion (1/17)	9.1 ± 5.7 (-23.5)	1.16 ± 0.05 (M)* (-13.4) 1.13 ± 0.09 (F)* (-15.0)	Reduced Ossification Sternebrae ↑
75	8/24	40.4 ± 12.6* (-26.3)	Lungs, mottled (1/16) Lungs, grey and mottled (14/16)	5.6 ± 6.8* (-52.9)	1.12 ± 0.07 (M)* (-16.4) 1.08 ± 0.10 (F)* (-18.8)	Sternebral Defect ↑ Reduced Ossification Sternebrae ↑

[a] Includes all plug-positive females.
[b] Includes only pregnant females.
[c] Includes plug-positive females surviving to scheduled sacrifice.
* $p<0.05$.
NS = not toxicologically significant.

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ACKNOWLEDGMENT

This work was supported by the National Institute of Environmental Health Sciences, National Toxicology Program under a Related Services Agreement with the U.S. Department of Energy under contract DE-AC06-76RLO 1830 at the Pacific Northwest Laboratory operated for the U.S. Department of Energy by Battelle Memorial Institute.

The excellent technical support in the Developmental Toxicology Laboratory of R.A. Ballou is appreciated.

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INTRODUCTION

Gallium arsenide (GaAs) is a crystalline compound which is being used extensively in newly developed electro-optical devices, microwave telecommunication systems, and computers because of its superior semiconductor properties. Industrial hygiene studies have indicated a potential for inhalation exposure to airborne gallium arsenide dust by workers involved in the manufacture of photovoltaic solar cells, cleaning of gallium arsenide ingots, and preparation of gallium arsenide wafers (Webb et al. 1984).

No studies addressing the potential for gallium arsenide exposure to cause development toxicity have been reported; however, other arsenic compounds, primarily the sodium salts of arsenate (As[V]) and arsenite (As[III]), have been shown to possess developmental toxicity in several laboratory animal species; the hamster (Ferm and Carpenter 1968), rat (Beaudoin 1974), and mouse (Hood and Bishop 1972). Several reviews on the developmental toxicity of various forms of arsenic are available (Barlow and Sullivan 1982; Willhite and Ferm 1984). In general, As[III] appears to be less teratogenic than As[V], but more embryolethal (Hood and Harrison, 1982; Willhite 1981). Both compounds are more toxic when they are administered by intraperitoneal (i.p.) or intravenous (i.v.) injection than when given orally. The predominant fetal abnormalities found following gestational exposure to As[V] are summarized in Table 1. Prenatal exposure to arsenic has also been reported to cause a significantly increased incidence of leukemia in the adult offspring (Osswald and Goerttler 1971).

Inorganic arsenic rapidly crosses the placenta in most laboratory species and in man. Lindgren et al. (1984) reported the placental transfer of arsenic following i.v. administration of radiolabelled arsenite or arsenate to pregnant mice or monkeys. Hood et al. (1987) measured the distribution, metabolism and fetal uptake of As[V] in pregnant CD-1 mice following i.p. administration of 20 mg/kg sodium arsenate or the per oral (p.o.) administration of 40 mg/kg on 18 dg; these doses approximated the maximum tolerated doses in terms of abortion or maternal death. Dams were killed at

intervals from 2 to 24 h posttreatment. Maternal blood levels following p.o. and i.p. dosing peaked at 1 h (2.05±1.05 µg/ml) and 10 min (6.93±1.00 µg/ml), respectively; fetal levels peaked at 6 h (0.77±0.27 µg/ml) and 2 h (3.49±2.95 µg/ml), respectively. All samples declined to their lowest levels within 18-24 h. Analyses of the fetal tissue for arsenic metabolites showed that methylated arsenic was present in all fetuses at all sampling times, that dimethylarsinic acid (DMA) greatly predominated over monomethylarsinic acid, and that the fetal DMA concentration exceeded inorganic arsenic within 4-5 h of treatment. The results of Hood et al. (1987) showed that the route of administration had a definite effect on the maximum concentrations achieved in the maternal blood and in the fetus, as well as an effect on the time required to achieve the maximum concentrations, but the route of administration did not appear to affect the degree of metabolism.

Hanlon and Ferm (1986) examined the maternal blood levels of arsenic following administration of sodium arsenate to pregnant hamsters with a minipump implanted on 6 dg. Dams were sacrificed at 24, 48, 72 and 168 h after implantation of the pump, and the concentration and chemical species of arsenic in the maternal blood was determined. At 48 h after implantation of a minipump containing 0.642 M arsenate (equivalent to to 200-223 µmoles/kg; 15-17 mg/kg), maternal blood levels reached ≈0.65 µg/ml and remained at that level through 13 dg (the end of the study). A maternal blood concentration of 4.3 µmole As/kg blood (0.32 µg/ml) on 8 dg is mildly teratogenic to golden hamsters, while a blood concentration of 8.4 µmole/kg (0.63 µg/ml) is frankly teratogenic (Ferm and Hanlon 1985).

Speciation of the arsenic present at 48 h showed that the plasma contained approximately 70% arsenate, 7% arsenite, and 26% methylated arsenic, while red blood cells (RBCs) contained approximately 46% arsenate, 14% arsenite, 10% methylated arsenic, and 30% nondialyzable arsenic. By 72 h the proportion of arsenic species in the plasma remained about the same while the proportions of the various forms present in the RBCs had changed considerably. At the 72-h timepoint the proportion of arsenate in the RBCs had declined by about 50% and the proportion of arsenite had doubled. The proportions of methylated and nondialyzable arsenic remained essentially unchanged. Thus,

arsenite and other metabolites are present in the blood of animals treated with arsenate.

Methylated forms of arsenic seem to be less developmentally toxic than the inorganic forms (Hood et al. 1982). Intraperitoneal injections of disodium methanearsonate or sodium dimethylarsinite (≈1,000 mg/kg or 500 mg/kg, respectively, which approximated the minimum lethal dose for pregnant hamsters) caused a high incidence of intrauterine mortality, but only a very few fetal abnormalities. A study in mice (Harrison et al. 1980) also showed that the dose required to produce embryotoxic effects in this species was approximately 100-fold greater than that required for As[III] or As[V] (Hood and Bishop 1972). Since these doses are well into the maternally toxic range it appears that methylated forms of arsenic are not selectively toxic to the fetus. In fact, methylation appears to be the most significant route of detoxification of inorganic arsenic in all laboratory species examined as well as in man (Crecelius 1977, and others).

A significant species difference in the distribution and clearance of arsenic exists between rats and mice, and in fact between rats and nearly all other mammalian species. While arsenic is cleared quite rapidly in the mouse (Hood et al. 1987; Hood et al. 1988), arsenic persists in the blood of the rat for long periods of time (Odanaka et al. 1980). This persistence is due to the strong (possibly irreversible) binding of arsenic to the hemoglobin of RBCs, presumably in its methylated form (Lerman and Clarkson 1983). The process appears to be saturable, due either to a limitation of the rate of methylation or the rate of binding to the hemoglobin (Vahter 1981). Once bound to the RBCs, however, the availability (Odanaka et al. 1980) and thus the toxicity of arsenic is greatly reduced.

Only a few studies specifically addressing gallium arsenide toxicity, distribution and metabolism have been reported. Since the arsenic atom of gallium arsenide exists in a reduced state (As^{-3}) as opposed to the more prevalent oxidized states of arsenic present in arsenites (As^{+3}) and arsenates (As^{+5}), the possibility for differences in the distribution and rate of metabolism exits. Furthermore, gallium arsenide is relatively insoluble and

the rate of absorption from the lung as well as the chemical species absorbed are not well known. However, Pierson et al. (1989) reported that crystalline gallium arsenide dissolved slowly in an aqueous solution that was made up to resemble lung fluid (Gamble's solution) and maintained at pH 7.4. During the dissolution process the arsenic in the gallium arsenide was found to migrate to the surface of the particles and solubilize preferentially following surface oxidation to a species resembling As_2O_3. After 10 days arsenic concentrations in the solution reached approximately 2 ppm while gallium attained a concentration of only 0.4 ppm. From their data they predicted that there would be a slow but continuous increase in the gallium and arsenic levels in the artificial lung fluid. Thus, these elements would be expected to be bioavailable following inhalation exposure to particulate gallium arsenide.

In a study designed to compare the metabolism and distribution of the arsenic in gallium arsenide with that in arsenate and arsenite, Rosner and Carter (1987) dosed Syrian golden hamsters intratracheally with 5 mg/kg arsenic as gallium arsenide, sodium arsenate, or sodium arsenite. The hamsters were killed at 1, 2, and 4 days after dosing, and arsenic levels in the urine, kidneys, liver, lungs, urine, and feces were measured. Arsenic from all three compounds was absorbed from the lung within 24 h; however, blood levels were greater in the animals treated with arsenite or arsenate than in those dosed with gallium arsenide. Arsenic blood levels in gallium arsenide treated animals peaked at 48 h posttreatment and remained constant through 4 days posttreatment, while arsenic from the other two compounds peaked much earlier and declined more rapidly. Arsenate and arsenite were cleared from the lung within 24 h, but 40% of the arsenide remained in the respiratory tract at that time. After 4 days approximately 50% of the arsenic in arsenite and arsenate had been eliminated from the urine, but only about 5% of the arsenic from arsenide. Approximately 50% of the administered gallium arsenide was eliminated in the feces within 4 days; approximately half of that was eliminated within 24 h. Extensive elimination of arsenic in the feces was not found for arsenite or arsenate; <10% was eliminated by that route.

Arsenic from gallium arsenide was metabolized to the same metabolites as were found for arsenite and arsenate. However, based on urinary excretion data, only about 10% of the arsenic from gallium arsenide was absorbed, much lower than for the other two compounds. The majority of the administered gallium arsenide was found in the feces, presumably from mucocilliary transport and subsequent swallowing. These results are consistent with those of Yamauchi et al. (1986), who found that 87.5% of the total arsenic from orally administered gallium arsenide was excreted in the feces of hamsters. Because of the low rate of absorption of arsenic from the pulmonary system of gallium arsenide treated animals, the bioavailability of arsenic is lower than that in animals treated with either arsenite or arsenate.

Rosner and Carter (1987) found dimethylarsinic acid was the major urinary metabolite for all three arsenic compounds. The ratio of dimethylarsinic acid to other arsenic metabolites (As[III], As[V], monomethylarsonic acid, and unknown) was approximately the same for arsenite, arsenate, and arsenide except at 1 day posttreatment where the the ratio of DMA to the others was greatest for gallium arsenide.

The present study was designed to assess the potential for inhaled gallium arsenide to cause developmental toxicity in rodents. In order to determine the concentrations of arsenic and gallium in the maternal blood and the fetus over the course of pregnancy, the study design also incorporated the analysis of arsenic and gallium in these tissues at three time points. Since inhalation exposure to gallium arsenide caused significant male toxicity in mice and rats in the 13-week subchronic study recently conducted for the NTP at Battelle-Pacific Northwest Laboratory, proven breeder male rats were exposed to gallium arsenide for 12 days and the levels of gallium and arsenic in the blood and the testes analyzed after the last day of exposure as an auxiliary to the developmental toxicity study. Sperm motility and epididymal sperm concentrations were also evaluated in the exposed males in order to determine the short-term effects (if any) of exposure to gallium arsenide on these parameters. The results from the male toxicity study will be presented in a separate report.

Gallium arsenide exposure concentrations of 0, 10, 37, and 75 mg/m^3 were chosen for the developmental toxicity study with the intent to produce a minimum, but observable, maternally toxic response at the highest concentration and to establish a no-observable-adverse-effect level (NOAEL) for developmental toxicity at the lowest exposure concentration. The middle exposure concentration was chosen with the intent of providing adequate data for interpreting the dose-response characteristics. The choice of these concentrations was based on the results of the repeated dose and 13-week subchronic toxicity studies recently conducted at Battelle-Pacific Northwest Laboratory for the NTP. Negative results at the lowest exposure concentration would provide an adequate margin of safety; 1,000-fold above the current TLV for arsenic which is 10 µg/m^3. The study protocol may be found in Appendix F.

MATERIALS AND METHODS

CHEMISTRY

Bulk Analysis and Storage

Chemical characterization of the gallium arsenide (GaAs) test material was presented in the October 26, 1988 report from Midwest Research Institute (MRI). Bulk chemical was identified as gallium arsenide (MRI Lot No. M051988, Batch 06). Cumulative analytical data indicated a purity of greater than 98%.

Elemental analysis results showed good agreement of gallium with theoretical values; however the elemental analysis results for arsenic were high; 52.8% compared to a theoretical value of 51.8%. No organic impurities were found to be present by elemental analysis. Spark-source mass spectrometry indicated that gallium and arsenic were the major components, and no individual impurities were present at concentrations greater than 100 ppm. All impurities totaled less than 170 ppm by spark-source mass spectrometry. Weight loss upon drying indicated 0.04 ± 0.01% water. Chelometric titration indicated a purity of 99 ± 1%.

The MRI recommended procedure was implemented at PNL and the bulk chemical purity was initially determined by elemental analysis. Subsequent chemical analyses prior to the start of the study were performed using chelometric titration; the test material relative purity was >99% and acceptable for the study exposures.

Gallium arsenide was stored at room temperature (≈20 °C) under an inert nitrogen atmosphere and protected from direct exposure to light as recommended by the NTP analytical contractor. In order to provide more convenient containers for day to day usage of the bulk chemical, the test material was subdivided into 32-oz jars. Additional details regarding test material receipt, usage, storage, and disposition may be found in Appendix A.

Test Chemical Stability Studies

Gallium arsenide undergoes oxidation in the presence of atmospheric oxygen; however, once a protective oxide surface layer is formed further oxidation of the material is retarded. The extent of this oxidation was examined by x-ray photoelectron spectroscopy (XPS) during the gallium arsenide repeated dose study conducted for the NTP at PNL. These studies indicated that the surface of the test material contained gallium oxide, arsenic trioxide, and gallium arsenide. The molar ratio of gallium oxide to gallium arsenide in the surface oxide layer ranged from approximately 0.24 to 0.30, whereas the molar ratio of arsenic trioxide to gallium arsenide ranged from approximately 0.18 to 0.25. The XPS analysis further indicated that the oxidation observed was confined to a surface layer depth of approximately 50 to 100 Å.

Test article stability was also investigated using x-ray diffraction (XRD) analysis to determine the crystalline phases present in samples of gallium arsenide from the exposure system during the first week of the study (XRD has a detection limit for various crystalline phases of about 1-2% by volume). No crystalline phases other than gallium arsenide were observed in any of the samples. Thus, although oxidized phases have previously been shown to be present using XPS and scanning-transmission electron microscopy, their concentration is less than the XRD analysis detection limit.

During the repeated dose and subchronic studies possible contamination of the test article by materials in the exposure generation system was investigated using x-ray fluorescence spectroscopy (XRF) and inductively coupled plasma-mass spectrometry (ICP-MS). Although gallium arsenide was expected to be quite stable within the generation system, small amounts of metallic impurities could be introduced into the system as a result of test chemical generation. Minor amounts of metallic impurities were detected in samples from the exposure chambers, but these impurities were all present at very low concentrations (<1% by weight). These analyses were repeated using XRF analysis during the first week of the developmental toxicity study and

impurities were again found to be <1% by weight. Additional details of test chemical stability measurements can be found in Appendix A of this report.

Monitoring of Test Chemical Concentration in Exposure Chambers

Gallium arsenide aerosol concentrations were monitored with real-time aerosol monitors (RAM-1, MIE Corp., Bedford, MA; Figure 1). These devices used a pulsed light-emitting diode in combination with a silicon detector to sense light scattered over a forward angle of 45° to 95° by the particles traversing the sensing volume. The instrument responded to particles in the 0.1 to 20 μm diameter size range.

The sample system used a valve to multiplex one RAM to two exposure chambers and either the control chamber or the room. The monitors were connected to the chambers through sample lines designed to reduce aerosol particle losses due to settling or impaction. The output of the RAM was automatically read and recorded by the data acquisition and control system. A Hewlett-Packard HP85B computer remotely controlled the selection of the correct sample stream and the acquisition of data from the monitor. The equations for the calibration curves were contained in the HP85B computer and were applied to the voltage data supplied by the RAM. Each chamber concentration was compared with limit values for the particular location. If a chamber concentration was beyond control limits, the HP85B computer would have sent the information to the executive computer (HP9816) for appropriate action.

Exposure concentrations for the developmental toxicity study were set at 10, 37, and 75 mg/m^3, and two additional chambers were maintained at concentrations of 0.1 and 1.0 mg/m^3 for the purpose of chamber monitor calibration. The 1.0 mg/m^3 chamber also housed male mice for a concurrent study (reported elsewhere).

The RAMs were calibrated against chamber concentrations determined from the analysis of glass-fiber filter samples obtained from the exposure chambers. Gallium arsenide was dissolved from the filters with 20% nitric acid, diluted, and the diluent analyzed for gallium using graphite furnace

atomic absorption spectrophotometry (GFAAS). Chamber concentrations determined from analysis of filter samples were correlated with voltage readings from the RAMs obtained concurrently with filter samples.

There was no on-line standard for gallium arsenide aerosol. Thus, to ensure that chamber concentrations were within 20% of the target exposure concentrations, filter samples were obtained daily from exposure chambers and the amount of gallium arsenide on each filter was determined gravimetrically. If the chamber concentration determined from the gravimetric analysis was not within ±20% of the chamber target concentration, RAMs were recalibrated using a chemical specific method, GFAAS. The minimum detectible limit (MDL) for each RAM was determined as the average blank plus three times the standard deviation of the blank, and was calculated to be 0.020, 0.013, and 0.006 mg/m^3 for RAM#1, RAM#2 and RAM#3, respectively.

During prestart tests for the recently conducted subchronic study the precision of each RAM aerosol monitor was estimated from the average %RSD of duplicate voltage readings obtained during routine RAM calibrations. In the absence of an on-line standard for the aerosol, this estimate included both the RAM variability and the variability associated with the generation and delivery system. Data from the prestart phase of the gallium arsenide subchronic study indicated the precision for repeated concentration measurements ranged from approximately 0 to 12 %RSD. Additional details of test chemical concentration monitoring may be found in Appendix A of this report.

GENERATION AND EXPOSURE METHODS

Exposure Chambers

The animals were exposed and maintained in inhalation exposure chambers developed at PNL (Moss et al. August 1980. "Whole-Body Inhalation Chambers." U.S. Patent No. 4,216,741; Moss 1980; Brown and Moss 1981; Moss et al. 1982) and now commercially produced by the Harford System Division of Lab Products, Inc., Aberdeen, MD. The chamber (Figure 2) facilitates multiple-tier

exposures of various laboratory rodent species to aerosol- and vapor-laden atmospheres. The total volume of the chamber is 2. m^3 with an active mixing volume of 1.7 m^3, the remainder being the inlet and exhaust volumes where animals are not placed. There are three levels of caging, each level split into two tiers which are offset from each other and from the chamber walls. Drawer-like stainless steel cage units composed of individual animal cages are suspended in the space above each tier. Stainless steel catchpans for the collection of urine and feces are suspended below each cage unit. Catchpans were left in position during each exposure period.

The chamber was designed so that uniform aerosol or vapor concentrations can be maintained throughout the chamber when the catchpans are left in position. Incoming air containing a uniform mixture of test material is diverted so that it flows vertically along the inner surfaces of the chamber. Eddies are formed at each tier as the aerosol or vapor flows past the catchpans. Stagnant zones that would normally exist above each pair of catchpans are cleared by exhaust flow through the space between the tiers. Aerosol or vapor reaching the lowest level is deflected across the bottom tiers by metal strips in the space between the catchpan and the wall. Tests have shown that aerosol or vapor concentrations uniform to within 3 to 8% throughout the chamber can be obtained repeatedly provided the aerosol or vapor is uniformly mixed before passing through the chamber inlet (Moss 1980; Moss et al. 1982). These tests were performed at PNL on a dynamically similar model of the chamber, as well as in the full scale chamber. Work at the Inhalation Toxicology Research Institute of the Lovelace Foundation, Albuquerque, NM has confirmed these findings (Griffis et al. 1981).

Exposure Suite System Description

The gallium arsenide exposures were conducted using an automated data acquisition and control system in an exposure suite (Figure 3) specifically designed for the study of hazardous insoluble aerosols. The suite consists of three exposure rooms and a suite control center room (only one of the exposure rooms was used for gallium arsenide exposures). A central computer monitored and controlled the basic chamber functions (i.e., test chemical concentration,

airflow, vacuum, temperature, and relative humidity) in the exposure room. The executive computer was a Hewlett-Packard (HP) Model 9816. All data acquisition and system control originated from this computer. All experimental protocols related to the data acquisition and control system (such as data channel assignments, monitoring frequencies and alarm settings) resided in the executive computer and were entered into tables accessed by menus. Data and comments from the exposure room were stored on separate magnetic diskettes by HP Model 9121 micro-floppy disk drives. Data and comments were printed on a thermal dot matrix printer (HP Model 2671G). Data were printed and stored immediately upon completion of the measurement to the "Daily Log". At the end of the day (24-hour period), the daily data were analyzed and a summary was printed which included the mean, standard deviation, percent relative standard deviation, maximum, minimum, and number of measurement for each set of data for the 24-hour period. A second printout provided a table of outliers (i.e. all data points which were beyond the critical limits defined in the protocol), and a third provided a list of all comments generated by the computer and operators.

Generation and Delivery System

The gallium arsenide aerosol generation and delivery system (Figure 4) was composed of five basic components; a Battelle-designed flexible-brush dust feed mechanism, a Trost Model GEM-T air jet mill, a cyclone separator, an aerosol charge neutralizer, and an aerosol distribution system.

The flexible-brush dust feed mechanism (Figure 5) employed a hopper into which the dry powder was poured. This hopper enclosed a randomly wound large bristle brush which continually rotated and stirred the powder and also delivered it through a small hole in the bottom of the hopper into a feed tube. The feed tube which was below and at a right angle to the hopper contained a spiral wound feed brush. The dust was conveyed through the feed tube at a controlled rate by a stepping motor connected to the feed brush. The dust dropped from the end of the feed tube and was aspirated into the Trost air-impact pulverizer. The performance of the generation system and the stability of the chamber concentrations was highly dependent upon the loading

of the hopper and upon the "free-flow" properties of the gallium arsenide dust. Material for each day was stored overnight in a nitrogen purged desiccator to achieve more uniform behavior of the material in the generator.

The Trost air-impact pulverizer or air mill (Model GEM-T, Garlock Plastomer Products, Newton, PA) used the fluid energy from opposing air jets to cause particle-to-particle, head-on impaction to deagglomerate and reduce the size distribution of the feed material. Following impaction, the particles were swept into a classification chamber where smaller ones exited to the next component of the generation system and larger ones were thrown to the perimeter by centrifugal force. These larger particles were reentrained into the impacting air jets for size reduction. Because of the hardness of the gallium arsenide test material, we believe that little size reduction actually occurred in the jet mill, but rather only deagglomeration of the particles fed from the flexible brush dust feeder.

The size distribution of the bulk material was such that the mass median aerodynamic diameter (MMAD) would be beyond the limits prescribed by the study protocol if it had been dispersed as supplied. As pointed out above, the Trost mill was not expected to provide a significant amount of size reduction. Therefore, a cyclone separator was installed and a significant fraction of the test material was removed to achieve the appropriate MMAD. Failure to remove the oversized particles would have resulted in clogging of many portions of the distribution system. A removable cup at the base of the separator collected the oversized material for proper disposal.

The actions of the flexible brush dust feeder, the Trost mill, and the cyclone tend to place an excess static charge on the aerosol particles which resulted in attraction of the particles to the walls of the delivery system thereby reducing the delivery efficiency. It may also result in altered deposition patterns within the respiratory tracts of the exposed animals. To control the excess charge, the aerosol was passed through a piece of plastic duct which had two 10 mCi ^{63}Ni-plated foils suspended in the center. The diameter of the duct and the activity of the foils were matched to provide

sufficient time for the aerosol to reach Boltzmann equilibrium at the system flow rate.

The aerosol which exited the charge neutralizer was conveyed across the hall from the suite control center into the exposure room by the aerosol distribution line (Figure 4). At each chamber location, an Air-Vac® (Air-Vac Engineering Co., Inc., Milford, CT) pump siphoned material from the distribution line into the chamber inlet. The 0.1 and 1 mg/m^3 exposure chambers were connected to a secondary distribution line which was coupled to the main line with a stainless steel tube and an Air-Vac pump. The concentration was further diluted in this distribution line. Each distribution line was terminated with a HEPA filter to remove any excess material not delivered to the exposure chambers.

Characterization of Test Article Concentration in Chambers

Examples of the buildup of aerosol concentration at the beginning of the exposure and the decay of concentration at the end of exposure with animals are shown in Figure 6. The rates were measured prior to the start of the subchronic study without animals (data not shown) and during this study with animals to determine if the presence of animals would have an effect. The time following the start of the exposure for the concentration to reach 90% of the final stable concentration in the chamber (T_{90}) and the time following the termination of generation for the aerosol concentration to decay to 10% of the stable concentration (T_{10}) were determined from the graphs. The values of T_{90} and T_{10} are summarized in Table 2.

The mean value for T_{90} without animals was approximately 11 minutes in Phase 1 of the subchronic gallium arsenide study and was 12 minutes with animals in the chambers. No significant differences were seen with the addition of animals into the exposure chambers. Minor discrepancies in the shapes of the buildup curves were due to the operation of the system. The theoretical value for the chamber with a flow of 15 cfm is about 12 minutes. A T_{90} value of 12 minutes was used in this study. T_{10} ranged from 7 to 10 minutes with animals in the chambers.

Uniformity of the aerosol concentration in the exposure chambers was measured prior to the start of the subchronic study without animals and once during the developmental toxicity study with animals in the chambers. The uniformity of the aerosol concentration was measured within each exposure chamber on the levels where animals were housed (Figure 7) as well as at the sample port for the on-line RAM. The sampling location for the uniformity measurements was just above and about 10 cm in from the front or back center of each cage unit where animals were housed. The uniformity data for each chamber are summarized in Table 3. Complete data may be found in Appendix C.

The variation of aerosol concentration measured from one sample port to another during the measurement procedure is the total port variability (TPV) and consists of both spatial and temporal variations. Two factors contribute to the TPV. The first, the between port variability (BPV), represents the spatial variation of the test material within the chamber. The second factor, the within port variability (WPV), represents the temporal fluctuation of the average aerosol concentration within the chamber during the time the measurements were taken. The temporal factor includes variations in the generation system as well as variation of the measurement instrument itself.

The WPV is determined from a minimum of three measurements taken at the on-line monitor port (1F) before, during, and after all other ports are measured. The TPV is determined from, at the minimum, the front and back ports at each level on which animals are housed, as well as one measurement from the on-line monitor port (whether or not animals are housed on that level).

The BPV is determined by applying the following equation:

$$BPV = \sqrt{(TPV)^2 - (WPV)^2}$$

Since the WPV is often determined from fewer measurements than the TPV, statistically it is possible for the WPV to be greater than the TPV. In these cases, the BPV is very small, but it cannot be distinguished from the WPV.

The BPV cannot be determined using the above equation as it yields the square root of a negative number, and so it is reported as unresolvable.

Cascade impactor samples (Mercer-style 7-stage impactor, In-Tox Products, Albuquerque, NM) were taken once each month from each exposure chamber during the subchronic study and the stages (glass coverslips lightly sprayed with silicone) were chemically analyzed for gallium by ICP-MS or GFAAS. The relative mass collected on each stage was analyzed by probit analysis (NEWCAS; Hill et al. 1977). The resulting particle size distributions are summarized in Table 4. The particle size distributions for the aerosol did not differ significantly with exposure concentration. In the Phase 1 effort for the repeated dose study, they were shown to be identical for both gallium and arsenic. The overall average MMAD of the aerosol in the developmental toxicity study was 1.1 µm with geometric standard deviation, ranging between 2.0 and 2.1.

In order to determine the persistence of the chemical in the chamber following exposure, the concentration of gallium arsenide in the 75-mg/m^3 chamber was monitored overnight following shutoff of the generation system. Measurements were made with and without animals present in the chamber. As shown in Figure 8, the concentration of aerosol in the exposure chamber was below 1% of the target concentration within 21 minutes and was below 0.1% within 35 minutes.

The exposure concentration data and daily performance for each chamber are presented in tabular and graphical form in Appendix C.

HEALTH AND SAFETY

Because gallium arsenide is insoluble in water, consideration was given to containment during the conduct of exposures, exposure room entry procedures, exposure chamber and room cleaning procedures, and solid waste disposal. Engineering controls, safe work practices, and personal protective device usage requirements were implemented to ensure maximal personnel protection and minimal potential for the spread of gallium arsenide dust throughout the work environment.

ANIMAL HUSBANDRY

CD (Sprague-Dawley) rats (373 females; 105 males) were received in good condition on 6/20/89 from Charles River Laboratories (Raleigh, NC). The birthdate given for all rats was 4/25/89. Upon receipt the rats were housed in room 530 of the LSL-II building for ≈4 weeks of quarantine prior to the start of exposure. During the quarantine period males and females were housed separately on stainless steel wire racks equipped with automatic waterers (≈5 rats per cage).

Swiss (CD-1) mice (368 females; 87 males) were received in good condition on 6/20/89 from Charles River Laboratories (Raleigh, NC). The birthdate given for all mice was 5/1/89. Upon receipt the mice were housed in room 530 of the LSL-II building for ≈4 weeks of quarantine prior to the start of exposure. During the quarantine period males and females were housed separately on stainless steel wire racks equipped with automatic waterers (≈10 mice per cage).

Three weeks into the quarantine period 10 animals of each species were randomly selected for preexposure health screen. Health screen evaluations included gross necropsy, histopathological evaluation of selected tissues, and culture of a nasopharyngeal wash for aerobic bacterial pathogens. Serum from each rat was tested at PNL for antibodies to *Mycoplasma pulmonis*, Sendai virus, pneumonia virus of mice (PVM), rat coronavirus/sialodacryoadenitis virus (RCV/SDAV), and Kilham rat virus/H-1 (KRV/H1). Serum from each mouse was tested at PNL for antibodies to *Mycoplasma pulmonis*, Sendai virus, pneumonia virus of mice (PVM), mouse hepatitis virus (MHV) mouse encephalomyelitis virus (GDVII) and minute virus of mice (MVM). (Appendix D). Another check for antibodies to these viral pathogens was performed on serum obtained from 10 females of each species at the final sacrifice. All health screen results were negative for significant pathogens and lesions. During the study period animals were observed daily for mortality, morbidity, and clinical signs of toxicity.

Rats were ≈14 weeks of age at the beginning of exposure, and mice were ≈13 weeks of age. Females which were not selected for this study were discarded after the start of the first exposure.

Just prior to mating during the fourth week, the males were individually caged in wire-bottom cages large enough to accommodate the placement of 2-4 females with each male. After mating, the animals were singly housed in an exposure chamber with the doors open. On the morning of the first exposure the rats and mice were moved to exposure room 404 of the LSL-II building and were housed continuously in the exposure chambers with the doors closed except during animal husbandry procedures.

Pelleted NIH-07 diet, manufactured by Ziegler Bros., Inc. (Gardners, PA) was available from slot feeders at all times except during the daily exposure period when feed was removed. Food was discarded each day and new food was added. Each milling of diet received was analyzed for contaminants by Lancaster Laboratories, Inc. (Lancaster, PA). All feed utilized was in compliance with NTP specifications.

Animal drinking water was supplied by the City of Richland municipal system. The water was softened in PNL facilities and supplied to the animals *ad libitum*. Rooms were illuminated by fluorescent lights with a 12-hour light, 12-hour dark, electrically operated cycle. Light started at 0600.

Airflow in the chambers was maintained by the vacuum in the central chamber exhaust duct. Chamber airflow was measured by a multiplexed orifice-meter system consisting of a calibrated orifice located in each chamber exhaust, a Validyne Model DP-45 pressure transducer, a Validyne Model CD-18 carrier demodulator, and a Validyne Model PM-12 digital voltmeter. Airflow was measured approximately every 3 hours throughout each 24-hour day. Each flow orifice was calibrated prior to the start of the study to within 0.5 cfm.

Temperatures of the exposure chambers and the exposure room were measured by resistance temperature detectors (RTDs). The RTDs were placed in a representative location in each chamber (a top sample port on the back side). Temperatures were automatically recorded at ≈3-hour intervals during

each 24-hour day. RTDs were calibrated prior to the start of the study to within 0.5°F of a certified mercury thermometer in a temperature-controlled water bath.

Percent relative humidity (%RH) was measured using an EG&G Model 910 chilled-mirror dewpoint hygrometer located in the exposure suite control center. Air from the exposure chambers was sampled from a representative location (a top port on the back side). Sample air from a particular location was routed by a 3-way valve multiplexing (MPX) system to either the exposure system exhaust or the dewpoint hygrometer for RH determination. The MPX valve was controlled by either a manual switch or by a computer-controlled relay. This allowed RH to be measured manually or automatically by the exposure system executive computer.

Percent RH was automatically recorded at regular intervals during the 24-hour day. Once the dewpoint had been determined by the hygrometer, the %RH was automatically calculated by the exposure system executive computer using the dewpoint value and the drybulb temperature (measured simultaneously at the same location by the RTD system) by applying a form of the Antoine equation for determination of saturation vapor pressure of water at a given temperature.

Calibration of the dewpoint hygrometer was established prior to the start of the study. The calibration procedure required comparison at three RH levels (≈30%, ≈50%, and ≈70%) of the %RH calculated by the monitor to measurements made by a calibrated portable hygrometer and RTD located near the chamber.

Summations of chamber temperature, %RH, and airflow, for the entire study are shown in Tables 5 and 6. These tables include the mean, the standard deviation (SD), mean expressed as a percentage of the target, the percent relative standard deviation (%RSD=100 x SD/mean), the maximum and minimum values, number of samples, and the percent of samples for which the value was within the specified operating range. A summary of the daily chamber environmental data and explanations of excursions of environmental

data are provided in the exposure operation discussion sheets included in Appendix C.

The mean temperature values in all chambers for the entire study were between 74.7 and 76.1°F, all within the specified limits of 72 to 78°F. In no case were more than 12% of the individual measurements in a single chamber out of the specified range. Extremes of the individual measurements ranged from 71.4 to 80.0°F.

The mean values of %RH in all chambers for the entire study ranged between 50.7 and 58.6% RH, all within the specified limits of 40 to 70%. In no case were more than 4% of the individual measurements in a single chamber out of the specified range. Extremes of the individual measurements ranged from 38 to 71%.

The mean values of chamber airflow in all chambers for the entire study were between 13.8 and 15.2 cfm (1 cfm = 1 air change per hour for the Hazelton 2000 chamber), all within the specified limits of 12 to 18 cfm. All (100%) of the measurements were within the specified limits.

DEVELOPMENTAL TOXICITY STUDY DESIGN

This portion of the study was comprised of the following experimental groups and numbers of animals:

	Number of Rats		Number of Exposure Concentrations	Total
0 mg/m^3	30	x	1	30
10 mg/m^3	31	x	1	31
37 mg/m^3	30	x	1	30
75 mg/m^3	30	x	1	30
Virgin (Test Groups)	10	x	3	30
Virgins (Controls)	10	x	1	10
				161

	Number of Mice		Number of Exposure Concentrations	Total
0 mg/m^3	23	x	1	23
10 mg/m^3	24	x	1	24
37 mg/m^3	22	x	1	22
75 mg/m^3	24	x	1	24
Virgin (Test Groups)	10	x	3	30
Virgins (Controls)	10	x	1	10
				133

Female rats and mice were weighed and individually identified by tail tattoos (AIMS®, Inc., Piscataway, NJ) 3 weeks after receipt. Weight data were acquired using the XYBION PATH/TOX System (XYBION, Medical Systems Corp., Cedar Knolls, NJ). Females were mated by caging 2 to 4 females overnight with each male. A positive mating was established in rats on the following morning by the presence of sperm in a vaginal lavage; if positive, this day was designated as 0 days of gestation (dg). In mice the presence of a vaginal plug indicated a positive mating. Positively mated females were weighed and randomly assigned to one of four exposure groups using body weight as the blocking variable. Mating was conducted for three consecutive nights to obtain 128 mated rats (≈32/group), and 93 mated mice (≈24/group)[1]. Groups from each of the three nights of mating are referred to, when necessary, as

[1]Approximately 32 plug-positive mice/group were initially designated for this study, but 27 mice were accidentally killed during transport to the exposure room. The other mice were transported separately.

gestation group A, B, or C. Following assignment to treatment groups the animals were individually caged in an exposure chamber with its doors open for acclimation until the start of exposure on 4 dg. Individual animal numbers and cage unit assignments are provided in Appendix F.

Positively mated and virgin female rats and mice were exposed to gallium arsenide in whole-body exposure chambers at target concentrations of 0, 10, 37, and 75 mg/m^3 for 6 hours + T_{90}/day, 7 days/week. Rats were exposed for 16 consecutive days, on 4 through 19 dg. Mice were exposed for 14 consecutive days, on 4 through 17 dg. Rats in gestation group A began exposure on 7/29/89, and groups B and C began on 7/30/89 and 7/31/89, respectively. Mice in gestation group A began exposure on 7/25/89, and groups B and C began on 7/26/89 and 7/27/89, respectively.

Virgins of each species, 10/species/group, were included to evaluate whether or not the state of pregnancy affected the sensitivity of the animals to the toxic effects of inhaled gallium arsenide.

The highest target exposure chamber concentration, 75 mg/m^3 gallium arsenide, was chosen based on the results of a 2-week range finding study conducted at PNL, and the two lower concentrations were chosen to determine the dose-response relationship of effects (if any) following gallium arsenide inhalation.

Body weights for mated female rats were acquired on 0, 4, 6, 10, 14, 17 and 20 dg. Body weights for mated female mice were acquired on 0, 4, 6, 9, 12, 15 and 18 dg. Virgin rats were weighed on exposure days 1, 3, 7, 11, 14, and at sacrifice. Virgin mice were weighed on exposure days 1, 3, 6, 9, 12, and at sacrifice. Animals were observed twice each day for signs of chemical toxicity, moribundity, and mortality, 7 days per week.

Rats surviving to scheduled sacrifice were killed by inhalation of ≈100% CO_2 on 20 dg (18 dg for mice) in the order of identification number. Rats in gestation groups A, B, and C were killed on 8/14, 15, and 16/89, respectively. Mice in gestation groups A, B, and C were killed in 8/8, 9, and 10/89, respectively. Animals were weighed and examined for gross tissue

abnormalities; the maternal liver and kidneys were removed and weighed. The uterus was removed, weighed, and opened. The number, position, and status (live, resorbed [early or late], or dead) of implants were recorded for each gravid uterus. Placentas were examined and discarded unless abnormal in appearance. Apparently non-gravid uteri from mated females were stained with 10% ammonium sulfide to detect possible implantation sites. Ovarian corpora lutea were counted for gravid females. Both ovaries from all females were fixed in Bouin's solution for 24 h, then transferred to 70% ethanol and sent to the NTP archives.

Live fetuses were weighed and examined for gross defects. After a lethal injection of Nembutal® (sodium pentobarbital), their sex was determined by internal examination of the gonads. Alternate live fetuses in the uterus of each litter (50%) were examined for visceral defects by dissection of fresh tissue (modified from the method of Staples 1974). The first live fetus to be examined in a uterus, #1 or #2, was determined by a coin-toss and the remainder chosen alternately from the first. The heads of the fetuses not selected for visceral examination were removed and placed in Bouin's fixative. After fixation, the heads were serially sectioned with a razor blade and examined for soft-tissue craniofacial abnormalities. All fetal carcasses, with and without heads, were prepared for skeletal staining. Cartilage as well as ossified bone was visualized by double-staining with alcian blue and alizarin red S. The individual identity of each fetal specimen was maintained throughout the study.

Virgins were weighed the day after their last exposure, killed, and examined for gross tissue abnormalities. Liver and kidney weights were obtained and the ovaries were fixed in Bouin's solution and sent to the NTP archives.

DISTRIBUTION STUDY DESIGN

This portion of the study was comprised of the following experimental groups and numbers of animals:

	Number of Sperm-Positive Rats		Exposure Concentrations	Total
Control	9	x	1	9
Test Groups	9	x	3	27
				36

Positively mated female rats designated for the distribution study were exposed to gallium arsenide in whole-body exposure chambers at target concentrations of 0, 10, 37, and 75 mg/m^3 for 6 hours + T_{90}/day, 7 days/week. The rats were exposed for 16 consecutive days, on 4 through 19 dg, or through the day proceeding their scheduled sacrifice.

Three females per group per time point were killed on 7, 14, and 20 dg. Rats surviving to scheduled sacrifice were killed by inhalation of 100% CO_2 in the order of increasing exposure concentration, controls first. Rats in the 7-, 14- and 20-dg groups were killed on 8/2, 9, and 15/89, respectively. Animals were weighed and examined for gross tissue abnormalities. A maternal blood sample was collected via cardiac puncture and the gravid uterus was removed. The "fetal" sample was an aliquot taken from a homogeneous mixture of the entire uterine contents (excluding the uterine wall) for the 7-dg time point, and from four homogenized fetuses per litter for the 14- and 20-dg samples. All samples were labeled, frozen immediately, and stored until analyses for gallium and arsenic. The following samples were analyzed:

	Time Points		Exposure Groups		Animals/ Group		Elements/ Group	Total
Maternal Blood	3	x	4	x	3	x	2	72
Uterine Contents	3	x	4	x	3	x	2	72
								144

ANALYSIS OF TISSUE SAMPLES FOR GALLIUM AND ARSENIC

Sample Preparation and Analysis

Weighed tissue samples ranging from approximately 0.1 to 2.0 g (wet tissue weight) were placed in a closed, acid digestion vessel (Parr Bomb, Model 4749, Parr Instrument Co., Moline, IL) and 1-3 ml of concentrated, ultrapure, nitric acid was added. Each vessel was sealed and the contents digested in a oven at 110-130°C for ≈3 h. After cooling, the bomb contents were quantitatively transferred to a volumetric flask and diluted to the appropriate volume with a final acid strength of ≈2% HNO_3. If necessary, subsequent dilutions were performed to produce a solution with a final gallium or arsenic concentration between 10 and 160 µg/l.

Samples were analyzed for gallium and arsenic using a Perkin-Elmer Model 5100 Atomic Absorption Spectrophotometer, with an HGA 600 Graphite Furnace equipped with Zeeman effect background correction and Model AS-60 Autosampler. For both gallium and arsenic analysis, the graphite furnace was equipped with graphite tubes fitted with a L'Vov platform constructed of pyrolytic carbon. Sample matrix interferences were attenuated through sample dilution and the addition of matrix modifier to the graphite furnace immediately prior to analysis of each sample. See Appendix B for details.

Standards were analyzed first to generate a calibration curve followed by analysis of samples. Standards were prepared from commercial spectrometric standards at concentrations of 10, 40, 100, and 160 µg/l each of gallium and arsenic in ≈2% nitric acid solution. A check standard containing 100 µg/l each of gallium and arsenic was analyzed after calibration and after approximately every five samples. The analyzed concentration of the check standard was required to be within ±10% of the known value or the instrument was recalibrated. All samples and standards were analyzed in duplicate.

With a few notable exceptions, recoveries from most tissues were generally in the range of 90-110% for gallium and arsenic. Recoveries for gallium and arsenic from whole blood were acceptable, provided each of these elements was present at a concentration of at least 1 µg/g. However, when

gallium and arsenic concentrations in blood were lower than approximately 1 µg/g, recoveries were very low and precision was poor. Detailed data on recoveries is presented in Appendix B.

The minimum detectable limit (MDL) was defined as the reagent blank concentration plus three times the standard deviation of the blank. MDL values were estimated for each element and tissue type and these values are reported in Table 7.

The minimum quantifiable limit (MQL) was defined as the reagent blank concentration plus ten times the standard deviation of the blank. The MQL for tissue analyses was calculated by multiplying the solution quantitation limit (µg/l) by the minimum sample solution volume (liters). MQL values were estimated for each element and tissue type (Table 8).

DATA ANALYSES

Means and standard deviations for animal data were calculated with SAS® statistical software on a VAX 11/780 computer. Mean fetal body weights, as the mean of litter means, were analyzed using the SAS General Linear Models (GLM) Procedure (SAS, 1985) with an analysis of variance (ANOVA) model for unbalanced data. Response variables, either body weight or the arc sine transformations of proportional incidence data, were analyzed against the class variable, "treatment", in a one-way ANOVA model. A Tukey's t-test (two-tailed) was used to assess statistically significant differences between control and exposed groups. If appropriate, the dose-response relationship was determined by means of an orthogonal trend test on arc sine transformed variables (Winer 1971). The litter was used as the basis for analysis of fetal variables.

DATA STORAGE

All residual animal tissues are stored in the LSL-II building, room 1428. All raw data and the study report are stored in the LSL-II building, rooms 1428 and 1229.

The duration of data storage will be in compliance with 21 CFR 58.195, or until NTP requests transfer of the data, whichever occurs first.

RESULTS

EXPOSURE GENERATION AND MONITORING

Gallium arsenide chamber concentration uniformity data and particle size were satisfactory. The mean test material concentrations for all exposure chambers were between 100 and 105% of targets, with relative standard deviations (%RSD) between 7 and 32% (Table 9). The acceptable limits for the %RSD in this study were widened to ±20% from ±10% due to the inherent difficulty in generating high yet stable aerosol concentrations. The %RSD value for the 37 mg/m^3 chamber fell outside the acceptable range because of several brief excursions in concentration. Accumulations of test material in the distribution line and chamber inlet Air-Vac® pumps occasionally broke loose and caused brief spikes in the chamber concentration. The duration of these spikes was usually quite short, but their magnitude was sufficient to skew the %RSD beyond the acceptable limits. Despite this, it is important to note that in no case were more than 6% of the concentration measurements in any single chamber out of range.

DEVELOPMENTAL TOXICITY: RATS

There were no deaths among exposed rats (Table 10). Many females in the 37- and 75-mg/m^3 gallium arsenide exposed groups exhibited dyspnea during the later portion of the exposure period; the incidence, duration and severity were related to exposure concentration. Approximately one-third of the animals in the 37-mg/m^3 group, but none in the 75-mg/m^3 group, were observed to be hyperactive during the middle portion of the exposure period. Some nasal discharge was noted in all exposed groups at various times during the course of exposure. Clinical signs did not differ significantly between mated and virgin female rats.

The predominant gross lesion observed in rats in the 37- and 75-mg/m^3 exposed groups at sacrifice was grey mottled lungs (27/30 and 28/30, respectively), while most animals in the 10-mg/m^3 group had red mottled lungs

(24/31). No other treatment-related lesions were observed. Gross lesions observed in virgin rats were similar to those seen in the mated females.

There were no effects on maternal body weight, on adjusted maternal weight gain[2], or on the body weights of virgin rats as a result of exposure to the concentrations of gallium arsenide used in this study (Tables 11 and 12). The mean uterine weight of pregnant rats was not significantly affected by exposure to gallium arsenide, and there were no treatment-related effects on mean maternal or virgin liver and kidney weights, or on the respective organ to body weight ratios. Individual weight records are presented in Appendix E.

The overall pregnancy rate in rats was 89% and did not differ significantly among treatment groups (Table 13). Exposure to gallium arsenide, which began on 4 dg (prior to implantation), had no effect on the number of corpora lutea, implantations, live fetuses, or resorptions per dam. However, the mean body weight in female rat fetuses was significantly reduced in the 37- and 75-mg/m^3 exposure groups, and in male fetuses in the 75-mg/m^3 group (Table 14). There were also slight reductions (not statistically significant) in the fetal weights of rats of both sexes in the lowest exposure group (10 mg/m^3), and for male fetuses in the 37-mg/m^3 group. Thus, there was a significant trend-effect on fetal weight versus increasing exposure concentration. There were no treatment-related effects on fetal liver weights or on fetal liver-to-body-weight ratios. The sex ratio of the fetuses represented as the mean percent of male fetuses per litter was unaffected by gallium arsenide exposure (Table 14). Reproductive measures for individual animals are presented in Appendix E.

Neither the types nor the incidence of malformations in rat fetuses were significantly affected by gestational exposure to gallium arsenide (Tables 15 and 16). However, the incidence of reduced ossification of the sternebrae (classified as a variation) was increased in an exposure-related fashion (Table 17), and was statistically significant for the 37- and 75-mg/m^3 groups.

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[2]Adjusted maternal weight gain = terminal body weight - uterine weight - 0-dg body weight.

There was also an increase in the incidence of incompletely ossified vertebral centra, but it was not statistically significant. The increase in incidences of these two sites of reduced ossification accounted the treatment-related increase in total variations. Other sites examined for reduced ossifications included the skull, phalanges, and vertebrae; the degree of skeletal ossification in these areas appeared normal for gestational age.

DEVELOPMENTAL TOXICITY: MICE

The 37- and 75-mg/m^3 exposure concentrations were quite toxic to the female mice. In the 75-mg/m^3 group 8/10 virgins and 8/24 plug-positive females were either found dead or moribund; in the 37-mg/m^3 group deaths were 8/10 and 5/22, respectively (Table 18).

Approximately one-half of the female mice in the 10- and 37-mg/m^3 gallium arsenide groups, and all mice in the 75-mg/m^3 group, exhibited dyspnea during some portion of the exposure period; the incidence, duration and severity were related to exposure concentration. Some mice in all exposed groups were reported as being hypoactive during the middle portion of the exposure period. Clinical signs in virgin mice were similar to those in mated females.

The predominant gross lesion observed at sacrifice in the 37- and 75-mg/m^3 exposed groups was grey and/or mottled lungs (17/17 and 15/16, respectively). Only two females in the 10-mg/m^3 group were found to have grey mottled lungs, all others in this group were normal. Lesions observed in virgin mice were similar to, but less frequent than, those found in positively mated females.

Maternal body weights and cumulative weight gains for plug-positive mice in the 37- and 75-mg/m^3 groups were significantly less than control dams on 9 through 15 dg; however, by 18 dg only the 75-mg/m^3 group weighed significantly

less than controls (Table 19 and Figure 9). Adjusted maternal weight gain[3] in mice was significantly less than controls for the 75-mg/m^3 group and showed a significant, decreasing trend with increasing exposure concentration. There were no significant differences in body weight among exposure groups for the virgin mice. The mean uterine weight of pregnant female mice in the 75-mg/m^3 exposure group was significantly decreased by exposure to gallium arsenide, and there was a significant trend effect between a reduction in uterine weight and increasing exposure concentration. There was no effect of treatment on mean maternal liver and kidney weights or on the kidney to body weight ratios; however, the liver-to-body-weight ratio for the 75-mg/m^3 group was significantly greater than the control group. The mean liver weight for virgin mice in the 75-mg/m^3 group was significantly greater than for the control animals, but the organ to body weight ratio was not significantly increased (Table 20). Kidney weights and kidney to body weight ratios for the virgin mice were unaffected. Individual organ weights are presented in Appendix E.

The overall pregnancy rate in mice was 87% and was not significantly different among treatment groups (Table 21). Exposure to gallium arsenide which began on 4 dg (prior to implantation) had no effect on the number of implantations. The significantly reduced corpura lutea count in the 75-mg/m^3 group is due to the presence of 7 litters with 100% early resorptions. In these litters the pregnancy was not maintained long enough to allow the corpura lutea to develop. The number and percent of resorptions per litter were significantly increased in the 75-mg/m^3 group, and the number of live fetuses per litter for that group was significantly decreased. An increase in the incidence of early resorptions was significantly correlated with increasing exposure concentration as was the incidence of litters having 100% resorbed fetuses. There were no litters with 100% resorbed fetuses in the control group for this study or for other recently conducted studies using CD-1 mice in this laboratory.

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[3]Adjusted maternal weight gain = terminal body weight - uterine weight - 0-dg body weight.

The mean fetal body weights for mice were significantly reduced in the 37- and 75-mg/m^3 exposure groups in both sexes (Table 22). There was also a slight, but not significant reduction in fetal weight for both sexes in the lowest exposure group which resulted in a statistically significant trend-effect on fetal weight versus increasing exposure concentration. There was no effect of treatment on the sex ratio of the mouse fetuses when represented as the mean percent of male fetuses per litter (Table 22). Reproductive measures for individual animals are presented in Appendix E.

In mice, values for the total number of fetal malformations per exposure group, the proportion of litters with malformations, or the mean incidence of total malformations were not significantly greater than controls following gestational exposure to gallium arsenide; however, all of these values increased with increasing exposure concentration (Tables 23 and 24). Furthermore, there were several malformations observed in exposed groups which were not present in the controls; cleft palate, encephalocele, and several vertebral defects. The vertebral defects, the incidence of which was significantly correlated to increasing exposure concentration, included missing or extra vertebrae, fused vertebral arches, and misshapen atlases or centra. When raw numbers were subjected to Chi-square analyses the number of fetuses with cleft palate or vertebral defects in the 75-mg/m^3 group was significantly greater than in the control group. This was also true for the number of litters containing fetuses with vertebral defects. Analysis of percent incidence data by ANOVA following arc sine transformation did not demonstrate statistical significance, but there is a clear treatment-related increase in the mean incidence of these malformations.

Similar statistical analyses of the data for fetal variations indicated significance in the 37- and 75-mg/m^3 groups relative to the control group for misaligned sternebrae, sternebral defects[4], and reduced ossification of the

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[4] Variations classified as sternebral defects include misshapen sternebrae or sternebral cartilage and ossification sites between the sternebrae. Variations classified as rib defects include fused or branched rib cartilage, and fused ribs.

sternebrae (Tables 24 and 25). The incidence of each of these sternebral variations was significantly correlated to exposure concentration. The mean incidence of total variations per litter also increased in a treatment-related fashion; however, the increases did not achieve statistical significance. Other sites examined for reduced ossifications included the skull, phalanges, and vertebrae; the degree of skeletal ossification in these areas appeared normal for gestational age.

DISTRIBUTION STUDY

Maternal blood concentrations of arsenic in the rat increased with increasing exposure concentration, and over the course of exposure within each exposure group with the exception of the 37 mg/m^3 group (Figure 10). Arsenic blood levels in this later group did not appear to increase between 14 and 20 dg; however, since the standard deviation for the 20-dg time point was greater than that for any other value the absence of a significant increase may be due to the greater variability in this group.

Arsenic levels in the 7-dg conceptus were below the limits of detectability for all groups, but by 14 dg arsenic was detectable in the 37- and 75-mg/m^3 groups. Concentrations in the conceptus continued to increase with advancing gestation, and by 20 dg arsenic was detectable in all exposed groups, but not in the controls. Although arsenic concentrations in the conceptus were well above the limits of detectability near the end of gestation, they remained nearly 100-fold lower than the levels found in maternal blood for all exposed groups.

Analyses of maternal rat blood and the conceptus for gallium showed a very different situation from that found for arsenic (Figure 11). Levels of gallium in the maternal blood for the 75-mg/m^3 group never exceeded 0.6 µg/g, while arsenic levels reached approximately 170 µg/g; thus, gallium levels were approximately 300-fold less than the arsenic levels. Furthermore, the increase in maternal blood gallium concentrations between the 37- and 75-mg/m^3 exposure groups was not proportional to the increase in exposure

concentrations. Fetal tissue on the other hand had gallium concentrations greater than those found in maternal blood for all exposed groups on both 14 and 20 dg. However, as was true for the maternal blood, the increase in fetal gallium concentration between the 37- and 75-mg/m^3 groups was not proportional to the differences in exposure concentration.

DISCUSSION

Gallium arsenide was administered to positively mated CD (Sprague-Dawley) rats and CD-1 (Swiss) mice at target concentrations of 0, 10, 37, and 75 mg/m^3 on 4 through 19 days of gestation (dg). Actual mean gallium arsenide concentrations achieved were between 100 and 10[illegible]% of the target concentrations. Inhalation parameters for chamber temperature, relative humidity, and airflow were all within acceptable ranges.

RATS:

In rats, the hyperactivity noted following exposure in the 37-mg/m^3 group was transient and probably not of great biological significance. This is further indicated by the fact that there was no reduction in either maternal body weight or the adjusted maternal body weight gain following gestational exposure to gallium arsenide. The presence of grey and mottled lungs in the 37- and 75-mg/m^3 groups accounts for the dyspnea observed in these groups during the latter part of the exposure period. Based on histopathological results from rats in the subchronic study on gallium arsenide the grey substance in the lungs is gallium arsenide. The red and mottled nature of the maternal lungs in the 10-mg/m^3 group is likely a result of the CO_2 asphyxiation. In the absence of an exposure-related decrease in adjusted maternal weight gain it is difficult to assess the degree to which this pulmonary toxicity may have affected fetal development.

No embryolethalicy resulted from gestational exposure to gallium arsenide particles, although a slight fetal growth retardation which was correlated to increasing exposure concentration, was present in fetal rats of both sexes. The growth retardation was indicated from reductions in fetal body weight and increases in the incidence of incompletely ossified sternebrae, both of which became significant at the 37-mg/m^3 exposure concentration. The presence of growth retardation is further substantiated when the fetal body weights and the incidence of incompletely ossified

sternebrae for the exposed groups are compared to respective values in the contemporary control data (Tables 26 and 27). There may also have been a treatment-related increase in the incidence of incompletely ossified vertebral centra since the incidence of this variation in the control group for this study is larger than in the contemporary control data.

The evid nt lack of embryotoxicity or severe fetotoxicity in the rat following gestational exposure to gallium arsenide was somewhat surprising in light of the results of the analysis of maternal blood for arsenic and gallium. Although the gallium levels were quite low at all times, arsenic levels in maternal blood exceeded 150 µg/g in the 75-mg/m^3 exposure group by 20 dg, the last day of exposure. These levels are about 240-fold greater than the blood level of arsenic that would be expected to cause developmental toxicity in the rat (Hanlon and Ferm 1986). Fetal levels of arsenic on the other hand remained low throughout the study and were never greater than 2.7 µg/g.

The teratogenic sensitivity of rats and hamsters to arsenate following i.p. injection appears to be similar. Ferm (1977) and Beaudoin (1974) reported the induction of developmental effects in hamsters and rats, respectively, following an i.p. injection of 20-30 mg/kg on 8 or 9 dg. Therefore, it may be expected that an arsenic blood level in the neighborhood of 0.63 µg/ml would have some teratogenic activity in the rat since this blood level was shown to be teratogenic in hamsters (Hanlon and Ferm 1986). However, in this study on gallium arsenide maternal blood levels as high as 55 µg arsenic/ml on 7 dg, rising to over 150 µg/ml by 20 dg, did not appear to have significant teratogenic activity. Clearly, the chemical species of the arsenic and/or its route of administration must be highly significant in determining its potential for developmental toxicity. Hood et al. (1987), working with mice, showed that the route of administration (i.p. versus oral [p.o.]) had a definite effect on the maximum arsenic concentration achieved in the maternal blood and the fetus, as well as an effect on the time required to achieve the maximum concentration, but that the degree of metabolism was not significantly affected. Blood arsenic levels were much greater following i.p. administration than they were when arsenic was given p.o. These results

corroborated an earlier report (Hood et al. 1978) where it was shown that the effect on the conceptus was greater at lower doses when arsenate was administered i.p. rather than p.o.

One of the primary routes of detoxification of inorganic arsenic is methylation. Methylated forms of arsenic do not possess nearly the potential to cause developmental toxicity in pregnant hamsters as do the unmethylated forms, e.g. arsenite and arsenate (Hood et al. 1982). In fact the doses of methylated forms of arsenic required to induce developmental toxicity exceed by 100-fold the doses of inorganic arsenic required to cause a teratogenic response in mice and hamsters (Harrison et al. 1980). Rats have been shown to be capable of methylating inorganic arsenic compounds and furthermore, to retain very high levels of tightly bound arsenic in their blood (Odanaka et al. 1980). Odanaka et al. (1980) showed that rats retained a greater proportion of an administered dose of arsenic than did mice and rabbits, approximately 44% of the arsenic dose remained in the rat blood. More than 98% of this residual arsenic was in a dimethylated form. The residual arsenic concentrations in similarly treated mice and hamsters were at too low a concentration to allow identification of the chemical species. The proportion of arsenic excreted in the urine of the rat in its dimethylated form was much lower than for the other two species, thus it is possible that the dimethylated arsenic is the form with the greatest affinity for the red blood cells.

In another study designed to assess differences in the metabolism of arsenic between mice and rats as well as to compare the *in vitro* binding capacities of arsenic in the blood of mice and rats, Vahter (1981) administered arsenic as $^{74}As(III)$ or $^{74}As(V)$ in single 0.4 mg/kg oral doses. The elimination rate of arsenic, as well as the degree of methylation, was lower in rats that in the mice. However, this is in contrast to results of Odanaka et al. (1980) who showed that the methylation rate between the two species was similar following an oral dose of 5 mg/kg, but that the methylated arsenic species formed in the rats was tightly bound to the intracellular protein of the erythrocytes. Differences in the results of these two studies may be attributed to the differences in dose levels, 0.4 vs. 5 mg/kg.

Although the metabolism of gallium arsenide in mice and rats, has not been widely studied, Rosner and Carter (1987) reported a study in which Syrian golden hamsters were dosed intratracheally with 5 mg/kg arsenic as gallium arsenide, sodium arsenate, or sodium arsenite. The hamsters were killed at 1, 2, and 4 days after dosing, and arsenic levels in the urine, kidneys, liver, lungs, urine, and feces were measured. Arsenic from all three compounds was absorbed from the lung within 24 h; however, blood levels were greater in the animals treated with arsenite or arsenate than in those dosed with gallium arsenide. Dimethylarsinic acid was the major urinary metabolite for all three arsenic compounds. The ratios of this metabolite to the other arsenic metabolites (As[III], As[V], monomethylarsonic acid, and an unknown compound) were approximately the same for arsenite, arsenate, and arsenide except at 1 day posttreatment where the the ratio of dimethylarsinic acid to the others was greatest for gallium arsenide. Thus, arsenic from gallium arsenide was metabolized to the same metabolites as were found for arsenite and arsenate. Dimethylated arsenic has also been shown to be the predominant human metabolite of arsenic (Braman and Foreback, 1973; Crecelius 1977; Buchet et al. 1980).

By taking the preceding results into account it may be hypothesized that the high levels of arsenic in the rat blood are essentially not biologically available, thus the lack of developmental toxicity in the rat. This is further supported by the extremely low levels of arsenic that we found in the uterine contents and fetuses in this study. It is probable that the uptake of arsenic from gallium arsenide inhalation exposure occurs at a relatively slow, but constant rate which allows for nearly complete methylation of all arsenic absorbed by the dam. These methylated arsenic species may then be tightly bound to the hemoglobin in the erythrocytes where they remain for long periods of time, but are not available for placental transfer.

Although neither maternal mouse blood nor the fetus was analyzed for arsenic and gallium, it may be assumed that the tissue arsenic levels were quite low. The situation in the mouse, which also rapidly metabolizes arsenic to methylated species, is somewhat different than that in the rat. Arsenic in the mouse is not tightly bound to the hemoglobin and is more

rapidly excreted. However, since placental transfer of inorganic arsenic species has been shown to be rapid in the mouse (Hood et al. 1987; 1988), it is likely that sufficient arsenic concentrations were available to the fetus to cause the observed developmental toxicity.

Based on distribution and elimination studies with gallium nitrate (Newman et al. 1979), gallium distribution and excretion appear to be rapid. Our results which show low concentrations of gallium in both maternal rat blood and the fetus and are consistent with a rapid distribution and elimination of gallium, and/or poor absorption.

MICE:

Pregnant mice were much more sensitive to the toxic effects of gallium arsenide than the rats. Maternal deaths in mice occurred in both the 37- and 75-mg/m^3 exposure groups; however, maternal body weights of survivors were significantly decreased for only the 75-mg/m^3 group. The presence of dyspnea and hypoactivity in at least some of the pregnant mice in all exposed groups indicated that there may have been some effect of gallium arsenide exposure on maternal health at the 10-mg/m^3 concentration. This was further supported by the grey mottled appearance of the maternal lungs, the severity and incidence of which was treatment-related; only two animals in the 10-mg/m^3 group had grey mottled lungs. However, the lack of any effect on maternal body weight or on adjusted maternal weight gain in the 10-mg/m^3 group makes it difficult to assess the degree to which the pulmonary toxicity may have affected the pregnancy.

The embryolethality evident in the 75-mg/m^3 group as a statistically significant reduction in the number of live fetuses per litter may have been caused by the severe maternal toxicity present at this exposure concentration. Although the lower exposure groups were not significantly affected, there was a statistically significant trend effect in the incidence of intrauterine death with increasing exposure concentration. Even at the lowest exposure concentration the incidence of intrauterine death was more than double that for the control group for this study as well as for the contemporary control

group (Table 28). The mean percent resorptions per litter in the contemporary control data was 5.8±7.0% (n=184 litters) and that for the control group in this study was 6.6±7.1%.

Fetal body weights for mice were reduced in all exposed groups with the reduction becoming statistically significant at the 37-mg/m^3 exposure concentration. The reduction in fetal body weight was accompanied by an exposure correlated increase in the incidence of sternebral defects and incompletely ossified sternebrae. Although not statistically significant, there was an apparent effect on both the fetal weight and the incidence of these variations at the 10-mg/m^3 exposure concentration. The fetal body weight was 5 and 6% less than controls for male and female fetuses, respectively, and the incidence of sternebral defects and incompletely ossified sternebrae was more than double that of the control group. The fetal body weights were similarly reduced relative to values for the contemporary controls, and the incidence of these variations was similarly increased above the contemporary control incidence; sternebral defects - 0.3±2.0%, and incompletely ossified sternebrae - 3.2±6.2% (Table 29). Thus, gestational exposure to gallium arsenide at these exposure concentrations appears to result in treatment-correlated fetal growth retardation. Since this occurs in the presence of apparent maternal pulmonary toxicity, but in the absence of a reduction in maternal weight gain at 10 mg/m^3, it is difficult to assess whether or not there is selective developmental toxicity.

The statistical significance of the increase in the incidence of fetal malformations in mice for any gallium arsenide exposed group is questionable, but several malformations were present in the exposed groups which were not present in the control group. A few of these malformations are relatively rare in this strain of mice, e.g. encephaloceles and missing or misshapen vertebrae. There is no previous occurrence of vertebral malformations in Swiss mice in the contemporary control data from this laboratory, and only one control fetus was found with an encephalocele (Table 30). Interestingly, these two malformations have previously been reported to occur as a result of gestational exposure of mice to arsenic compounds (Hood and Bishop 1972).

CONCLUSIONS

In conclusion, gestational exposure of Sprague-Dawley rats to gallium arsenide resulted in maternal toxicity as evidenced by apparent pulmonary toxicity at 37 and 75-mg/m^3. However, developmental toxicity in the form of concentration-related growth retardation evidenced as reduced fetal body weight and an increased incidence of fetal variations was present at the lowest exposure concentration, 10 mg/m^3, and became statistically significant at the next highest concentration, 37 mg/m^3. There was no evidence of embryotoxicity or frank teratogenicity. The maternal NOAEL for inhaled gallium arsenide in rats was 10-mg/m^3. The NOAEL for developmental toxicity was 10 mg/m^3 if determined solely on the basis of adverse effects achieving statistical significance; however, nonsignificant indications of developmental toxicity were present at this exposure concentration.

Determination of gallium and arsenic concentrations in maternal blood and in the uterine contents of rats showed that arsenic concentration in the maternal blood achieved significant levels, increased with exposure concentration, and over the course of exposures. Arsenic concentrations in the developing fetus were elevated above controls in a concentration-related fashion, but were far exceeded by maternal blood concentrations. The excess arsenic in the maternal blood was probably tightly bound to hemoglobin in the erythrocytes, and thus was not available for placental transfer. Gallium concentrations were low in both the maternal blood and in the conceptus, but were elevated above controls in the highest exposure group. The concentration of gallium in the 20 dg fetus was greater than in maternal blood.

Swiss (CD-1) mice were much more sensitive to the effects of gallium arsenide than were the rats. The two highest exposure concentrations were lethal to some pregnant animals, and body weights and body weight gains were reduced in survivors of both of these groups. A NOAEL for maternal toxicity in mice was not achieved in this study. Developmental toxicity was evident in all three exposed groups, and became statistically significant at the 37-mg/m^3 exposure concentration. There were signs of embryolethality, fetal growth

retardation, and a slight, but not significant, increase in the incidence of fetal malformations. A NOAEL for developmental toxicity was not achieved for mice in this study.

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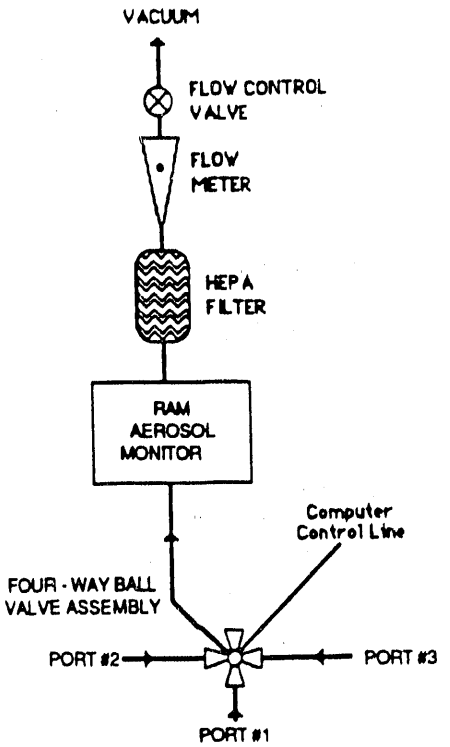


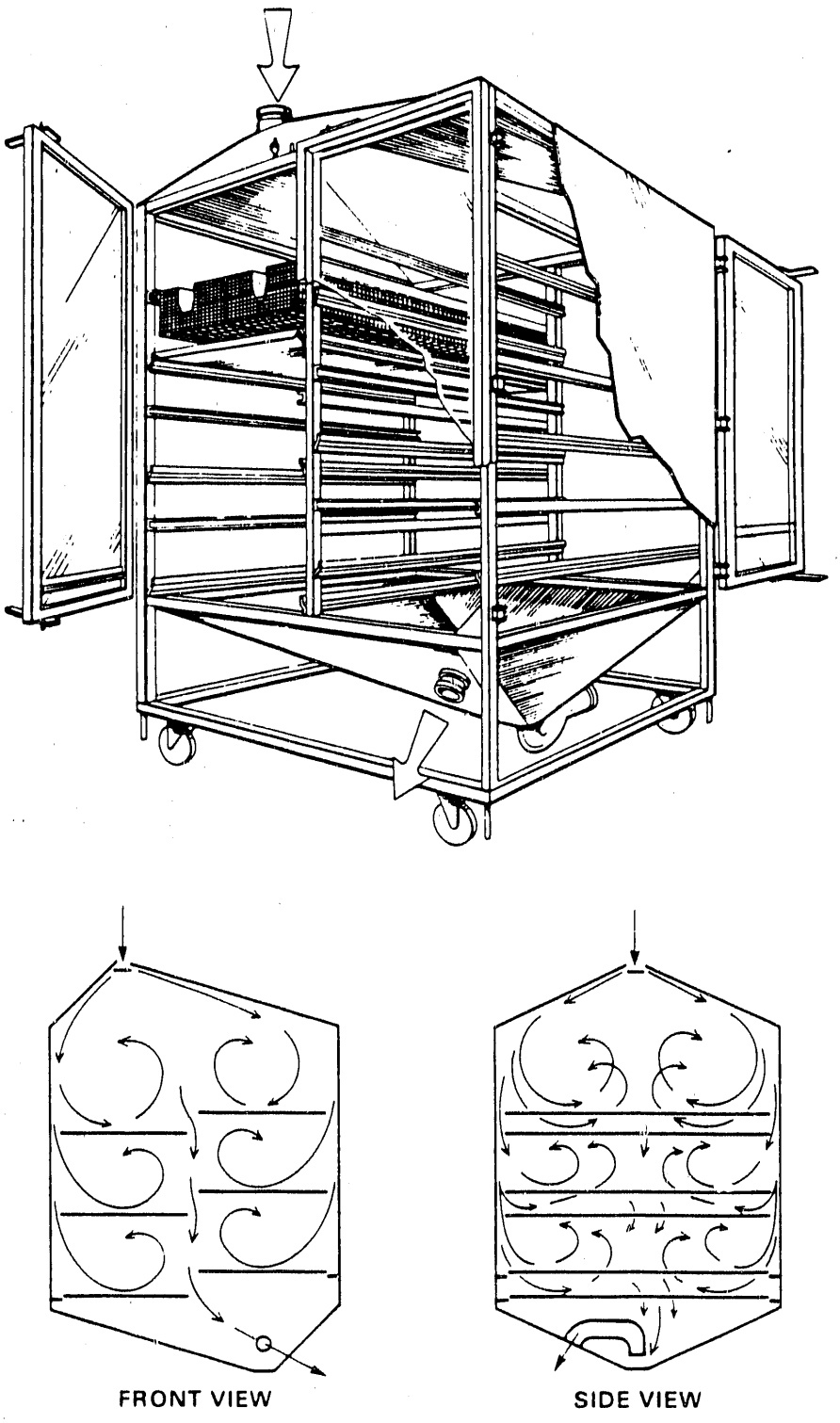
PORT

RAM	1	2	3
1	NOT USED	75 mg/m^3	37 mg/m^3
2	Room	10 mg/m^3	37 mg/m^3
3	0 mg/m^3	1.0 * mg/m^3	0.1 mg/m^3

* Concentration data recorded only during animal exposures.

☐ = Monitored for calibration purposes only.

FIGURE 1. Gallium Arsenide Inhalation Developmental Toxicity Study: Chamber Concentration Monitoring System



Moss et al. 1982. Amer. Ind. Hyg. Assoc. J. 43(4)244-249

FIGURE 2. Gallium Arsenide Inhalation Developmental Toxicity Study: Inhalation Exposure Chamber U.S. Patent 4,216,741 (Top: Oblique Cutaway View; Bottom: Airflow Patterns)

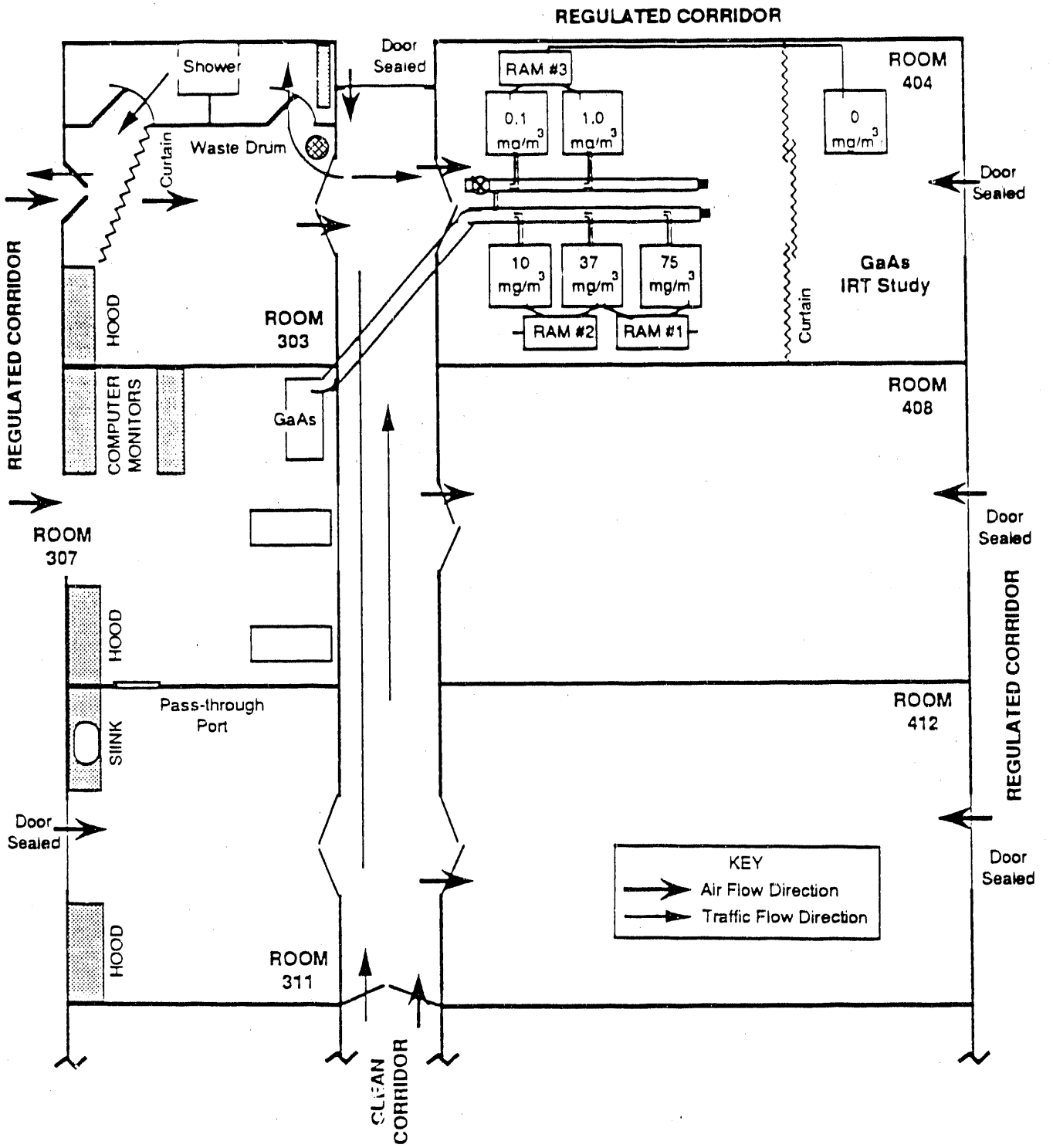


FIGURE 3. Gallium Arsenide Inhalation Developmental Toxicity Study: Study Exposure Suite

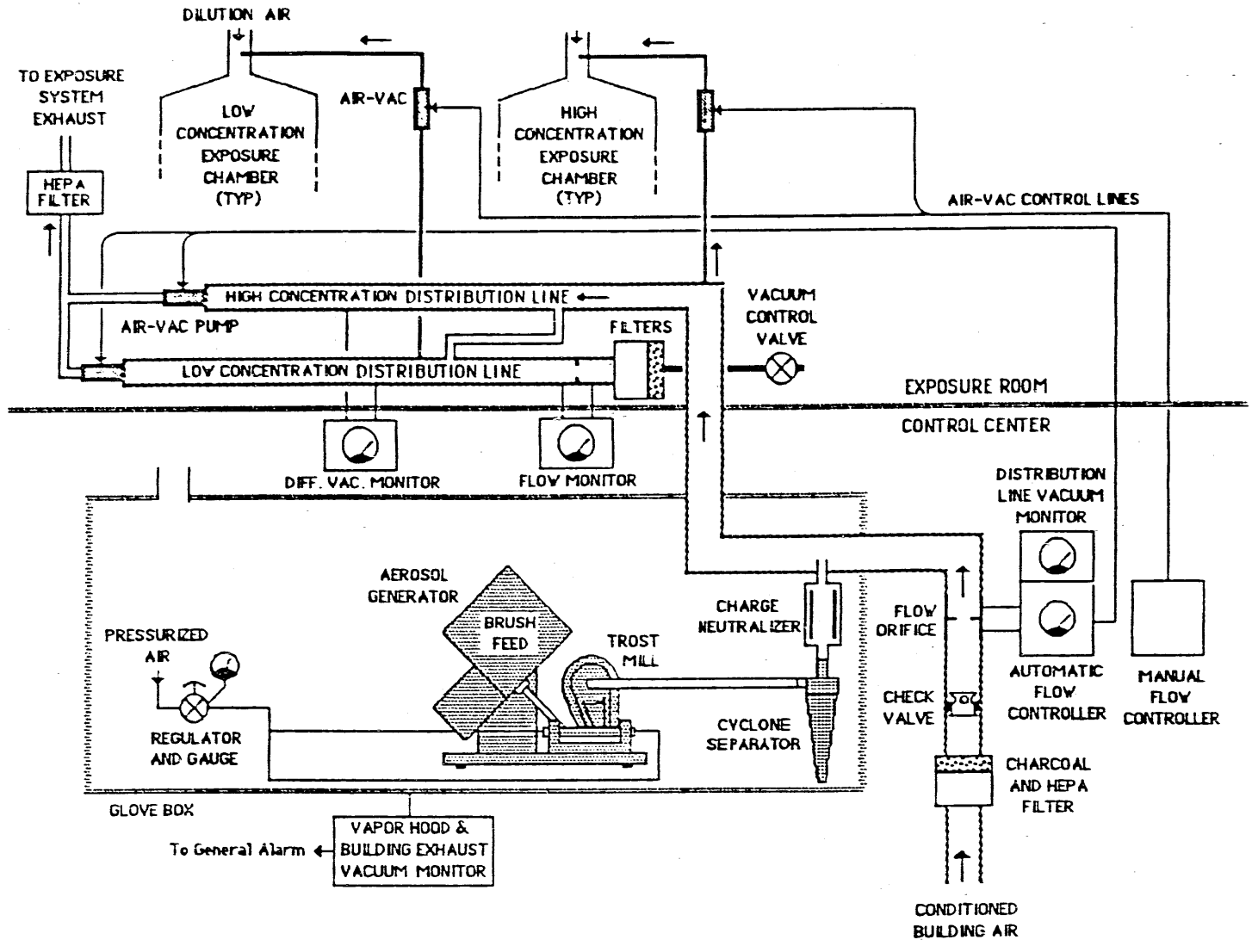


FIGURE 4. Gallium Arsenide Inhalation Developmental Toxicity Study: Aerosol Generation and Distribution System

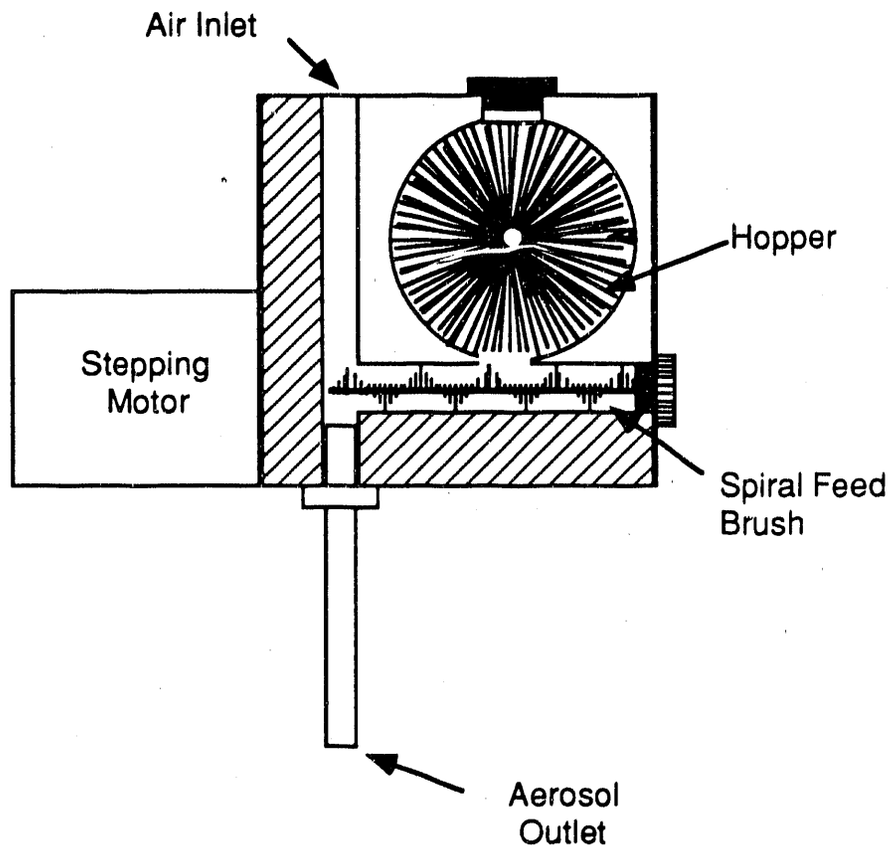
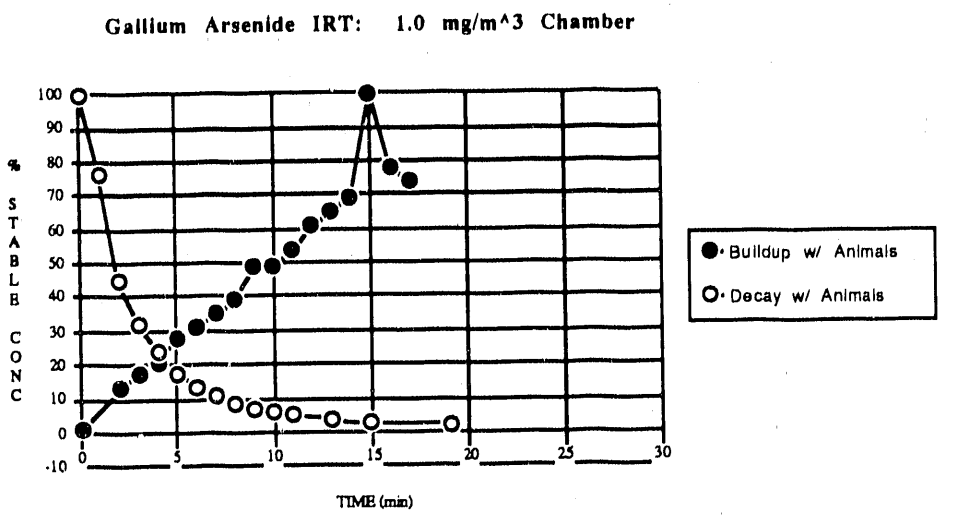


FIGURE 5. Gallium Arsenide Inhalation Developmental Toxicity Study: Cross-Section Schematic of the Battelle-Designed Flexible-Brush Dust Feed Mechanism U.S. Patent 4,424,896



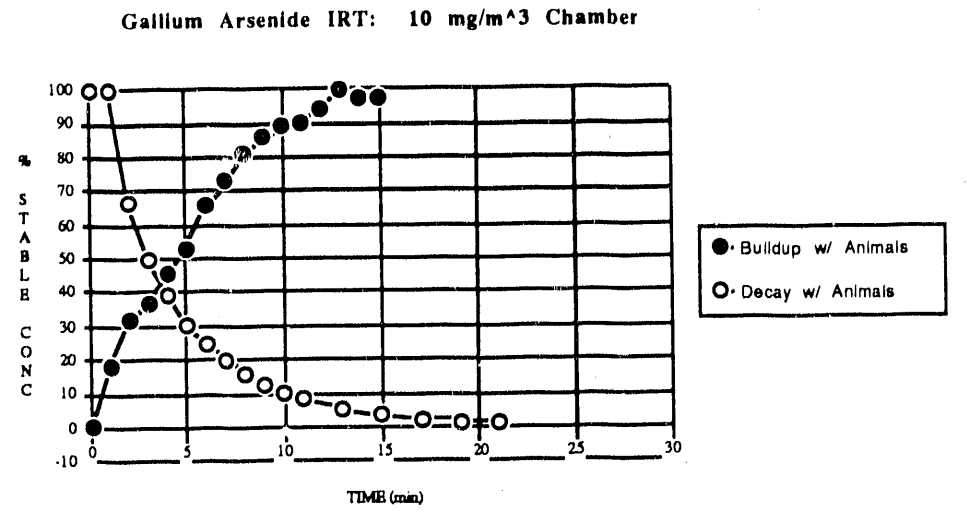
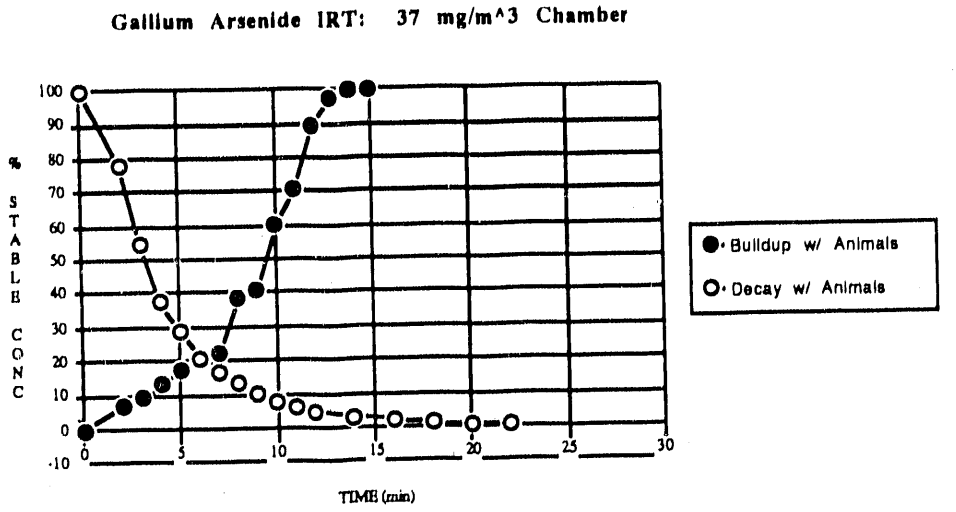


FIGURE 6. Gallium Arsenide Inhalation Developmental Toxicity Study: Buildup and Decay Curves of Concentration in Animal Chambers



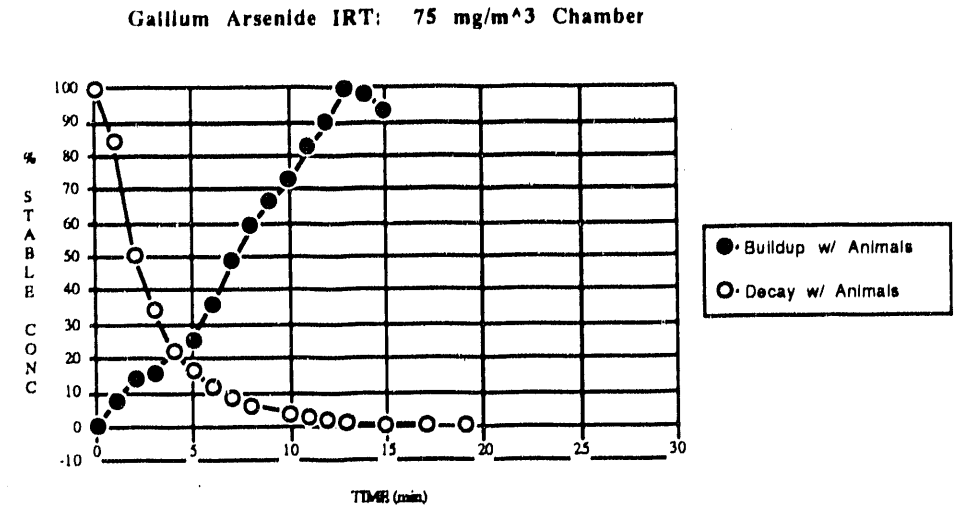


FIGURE 6. (cont) Gallium Arsenide Inhalation Developmental Toxicity Study: Buildup and Decay Curves of Concentration in Animal Chambers

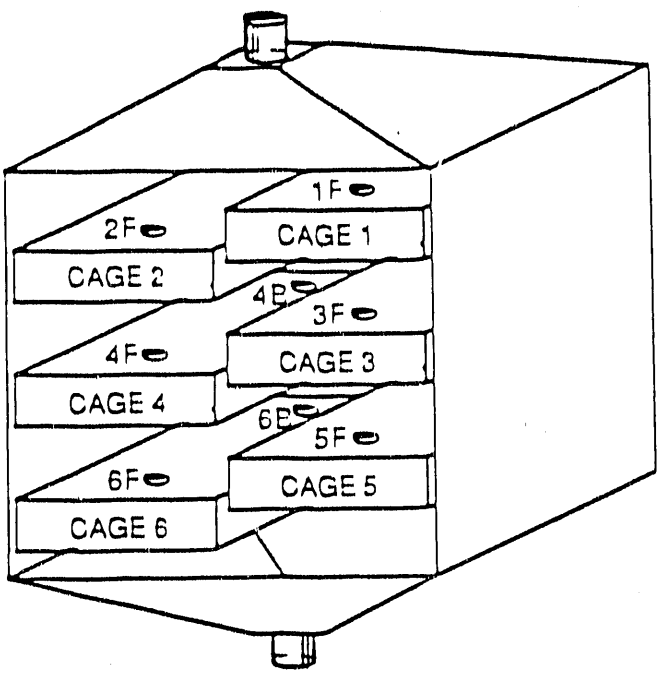


FIGURE 7. Gallium Arsenide Inhalation Developmental Toxicity Study: Animal Exposure Chamber Schematic Showing Approximate Sampling Locations (F = Front; B = Back)

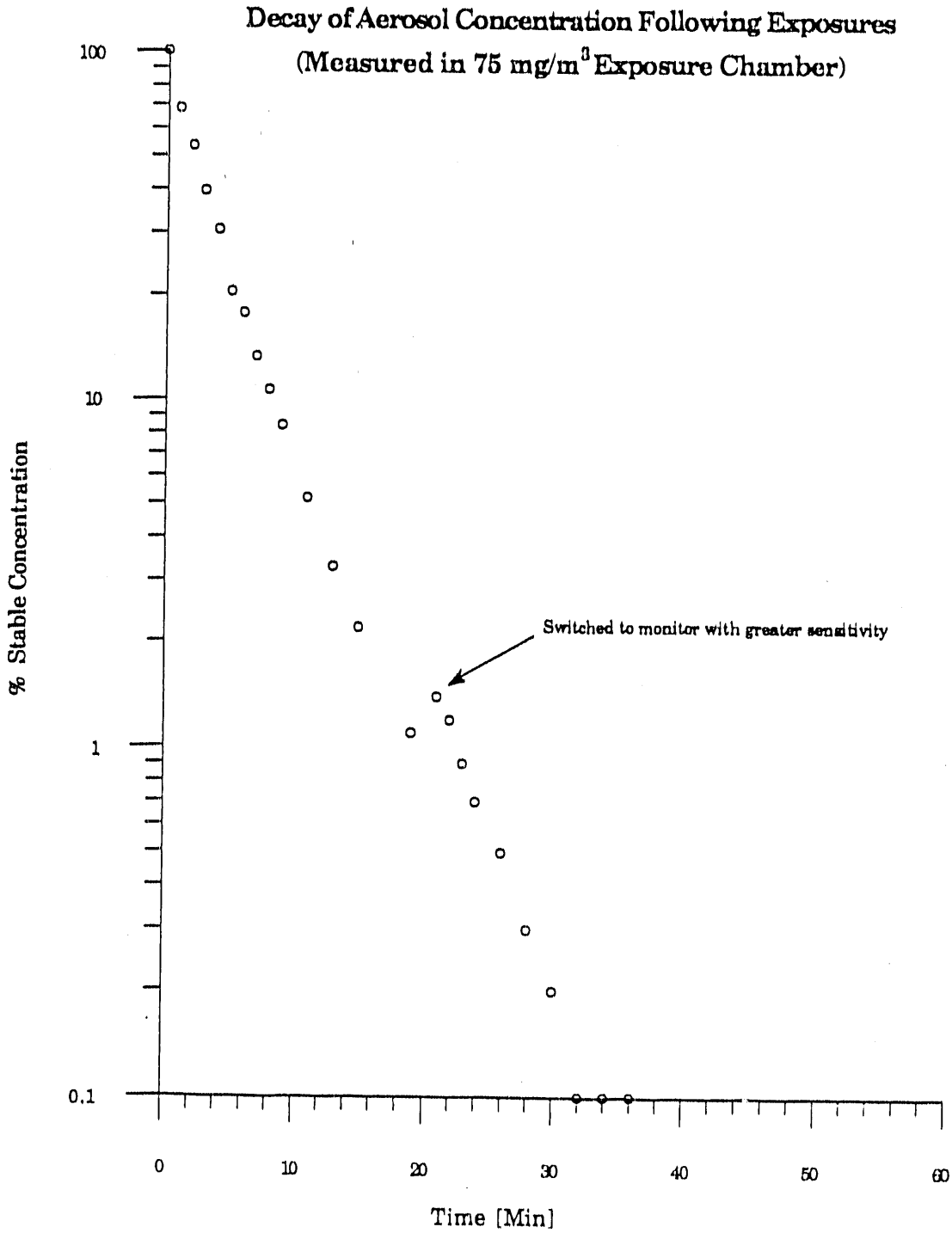


FIGURE 8. Gallium Arsenide Inhalation Developmental Toxicity Study: Persistance of the Chemical in the Chamber Following Exposure of Animals.

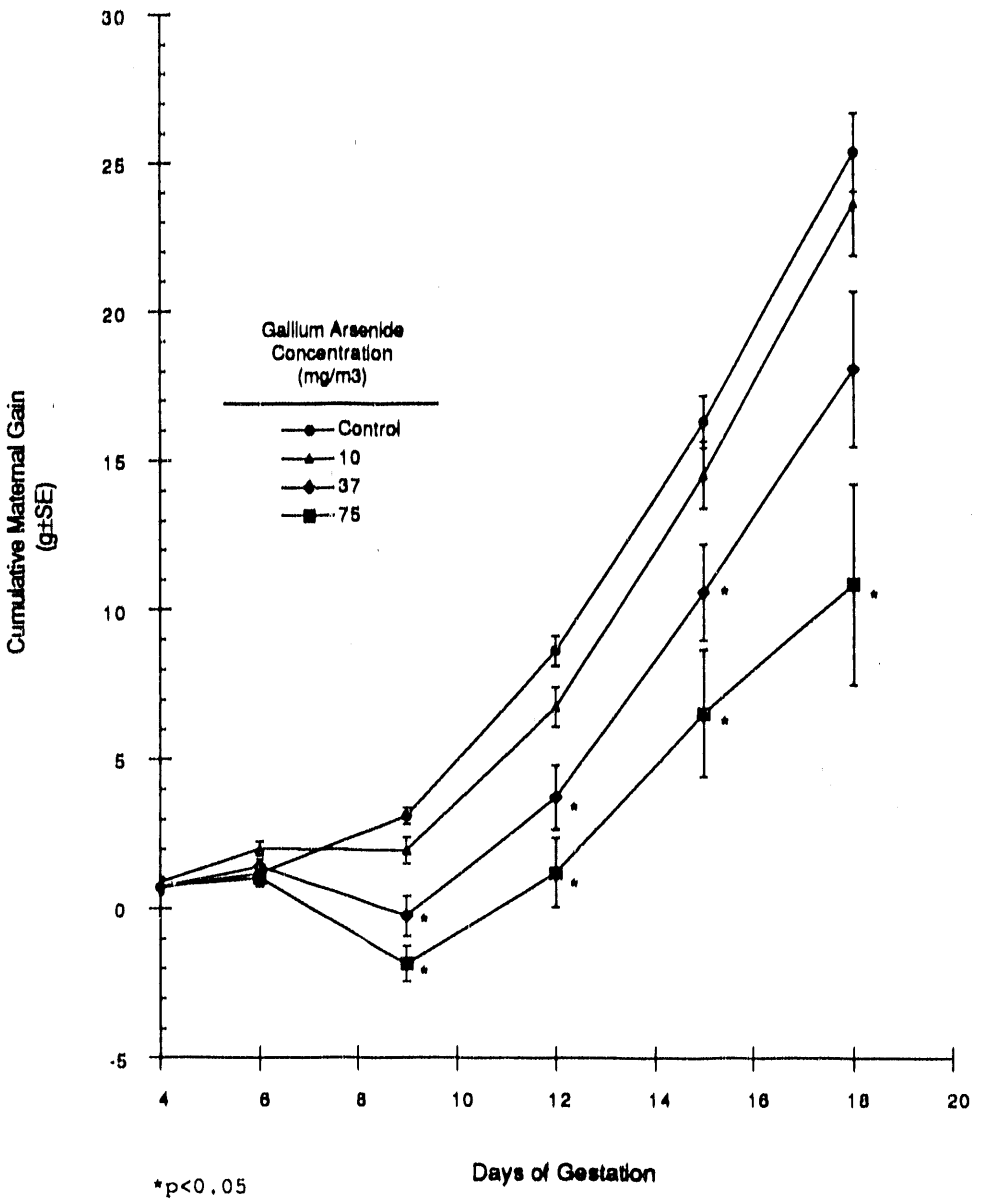
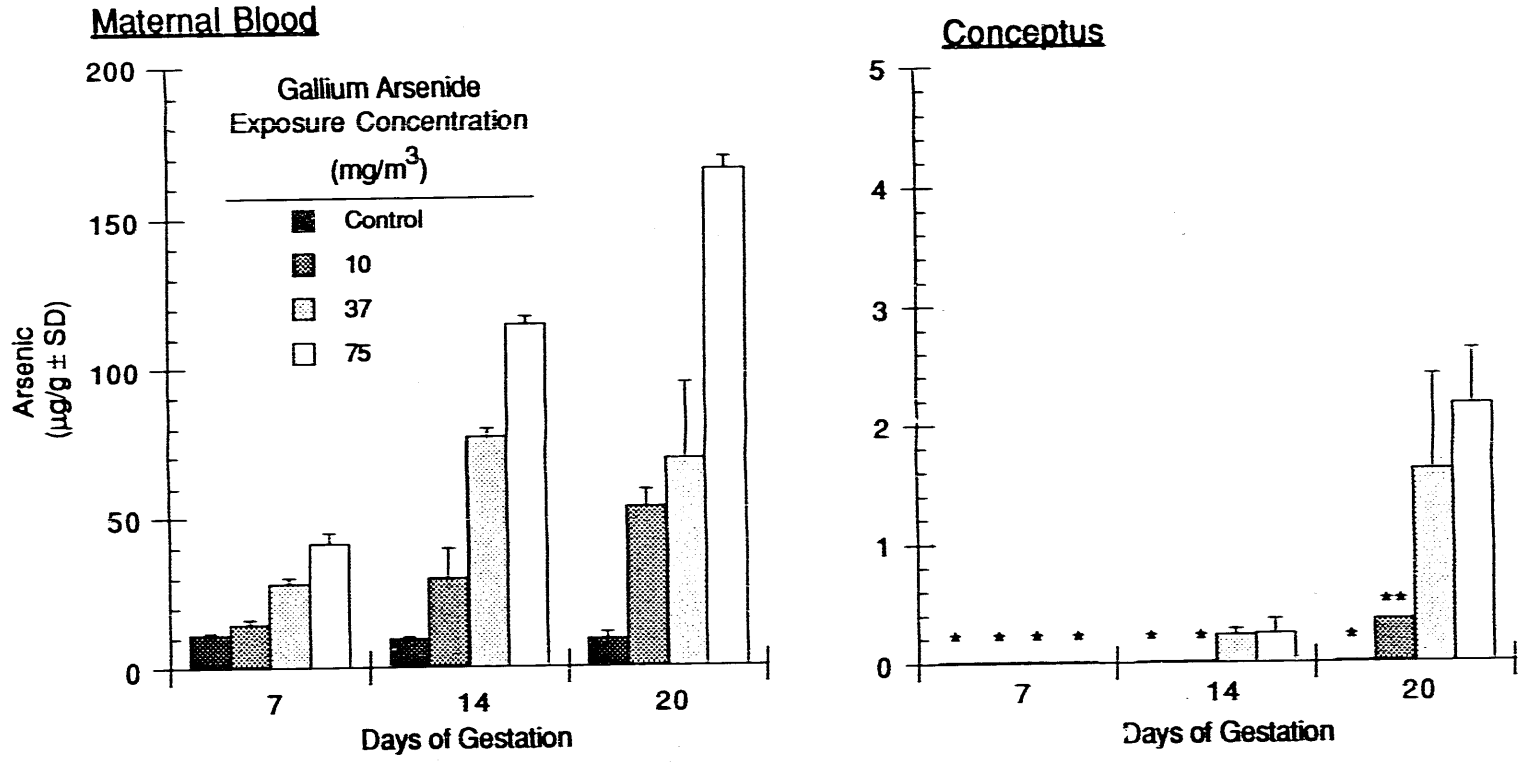
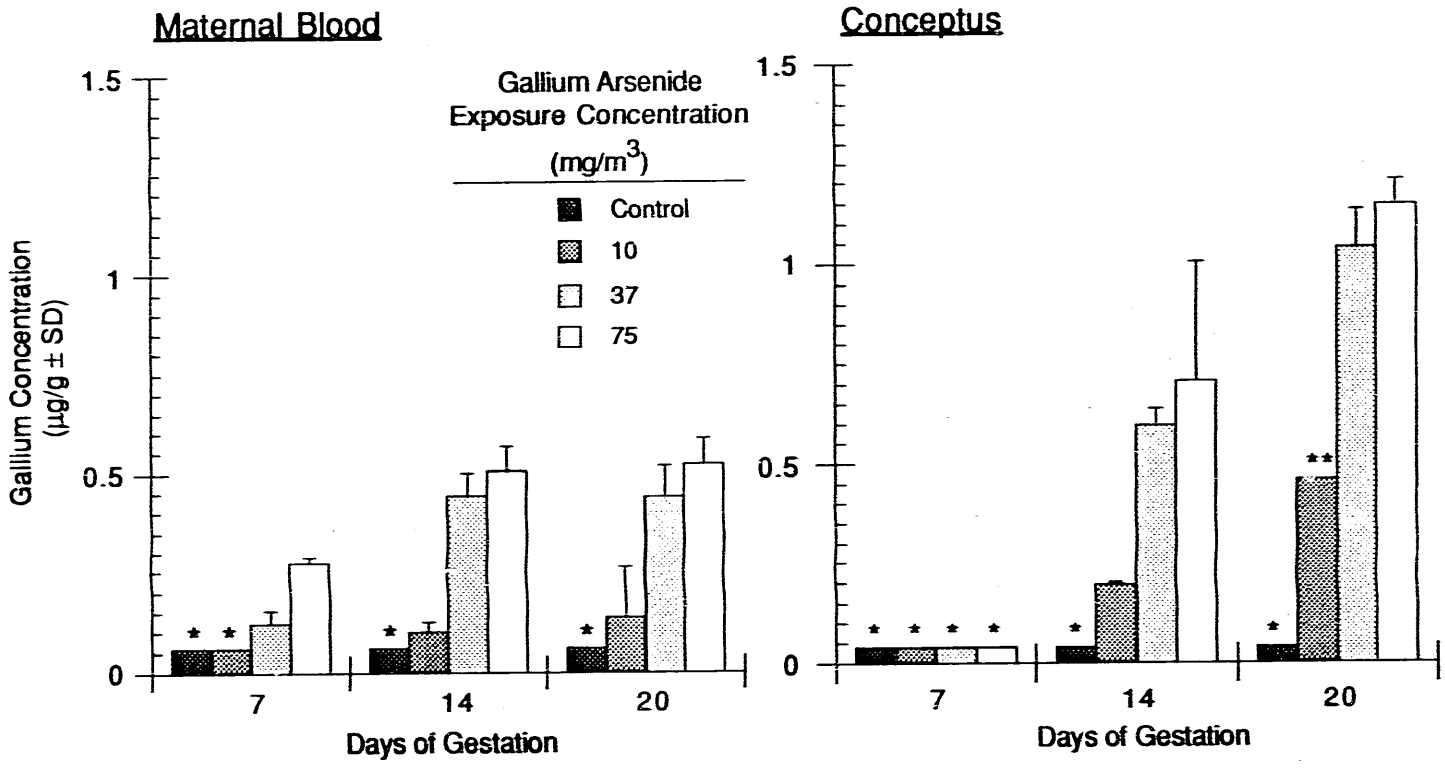


FIGURE 9. Gallium Arsenide Inhalation Developmental Toxicity Study: Cumulative Maternal Weight Gain in Mice



*Below the minimum detectable limit.
**N=2.

FIGURE 10. Gallium Arsenide Inhalation Developmental Toxicity Study: Arsenic Levels Found in the Maternal Blood and in the Conceptus of Rats Following Gestational Exposure to Gallium Arsenide. Note the Large Difference Between the Concentration of Arsenic in the Maternal Blood and in the Conceptus.



*Below the minimum detectable limit.
**N=2.

FIGURE 11. Gallium Arsenide Inhalation Developmental Toxicity Study: Gallium Levels in Maternal Blood and the Conceptus of Rats Following Gestational Exposure to Gallium Arsenide.

TABLE 1. Fetal Abnormalities Induced by Arsenate.

Hamsters[1]	Mice[2]	Rats[3]
Exencephaly	Rib malformations	Vertebral defects
Rib malformations	Vertebral defects	Renal agenesis
Renal agenesis	Exencephaly	Rib malformations
Other urogenital abnormalities	Short jaw, protruding tongue	Anophthalmia
Cleft lip and palate	Hydrocephalus	Gonadal agenesis
Anophthalmia	Exophthalmia	Exencephaly

[1]Ferm et al. 1971.
[2]Hood and Bishop 1972.
[3]Beaudoin 1974.

TABLE 2. Gallium Arsenide Inhalation Developmental Toxicity Study: Summary of T_{90}[a] and T_{10} Data.

Target Conc. (mg/m^3)	T_{90} [min]		T_{10} [min]	
	Prestart	Poststart	Prestart	Poststart
1	9	15	13	7
10	12	11	10	10
37	14	12	10	9
75	14	12	9	7

[a] A value of 12 minutes was used for T_{90} for the study.

TABLE 3. Gallium Arsenide Inhalation Developmental Toxicity Study: Summary of Chamber Uniformity Data (On-line Measurements Only).

Target Conc. (mg/m^3)	TPV [%RSD]		WPV [%RSD]		BPV [%RSD]	
	Prestart	Poststart	Prestart	Poststart	Prestart	Poststart
1	1.1	2.5	1.1	4.7	0.4	--[a]
10	1.2	1.0	0.7	0.7	0.9	0.7
37	2.2	3.4	1.4	4.1	1.8	--
75	0.7	2.2	0.4	2.3	0.6	--

TPV = Total Port Variation. Acceptable limit ≤ 7% RSD.
WPV = Within Port Variation. Acceptable limit ≤ 5% RSD.
BPV = Between Port Variation. Acceptable limit ≤ 5% RSD.
[a] When the WPV is greater than the TPV, the BPV is very small and it cannot be resolved from the WPV.

TABLE 4. Gallium Arsenide Inhalation Developmental Toxicity Study: Aerodynamic Particle Size Data for All Exposure Chambers. (Chambers were sampled with Mercer-style impactors and the values were derived from probit analysis of the data.)

Target Conc. (mg/m^3)	MMAD [μm]	GSD
1	0.8	2.1
10	1.1	2.0
37	1.2	2.0
75	1.3	2.0

TABLE 5. Gallium Arsenide Inhalation Developmental Toxicity Study: Summation of Chamber Environmental Data for Rats.

TEMPERATURE (°F)[a]

Target Concentraton (mg/m^3)	Mean±SD	Percent of Target±%RSD	Maximum	Minimum	Number of Samples	Number Samples In Range	Percent of Samples In Range
Room	70.0±2.5	97±4	74.7	63.4	146	91	62
0	75.6±1.4	101±2	78.2	71.7	136	134	98
10	75.3±1.5	100±2	78.3	71.5	136	130	96
37	75.7±1.7	101±2	80.0	71.4	138	122	88
75	74.9±1.6	100±2	78.7	71.7	129	123	95

[a]Acceptable Range = 72 to 78°F for the exposure chambers and 69 to 75°F for the exposure room.

RELATIVE HUMIDITY (%RH)[b]

Target Concentraton (mg/m^3)	Mean±SD	Percent of Target±%RSD	Maximum	Minimum	Number of Samples	Number Samples In Range	Percent of Samples In Range
0	58.6±5.0	106±9	69	45	139	139	100
10	57.9±5.2	105±9	71	48	141	140	99
37	56.9±7.1	103±12	68	39	141	138	98
75	55.3±7.4	100±13	66	38	141	138	98

[b]Acceptable Range = 40 to 70%.

AIRFLOW (CFM)[c]

Target Concentraton (mg/m^3)	Mean±SD	Percent of Target±%RSD	Maximum	Minimum	Number of Samples	Number Samples In Range	Percent of Samples In Range
0	15.2±0.7	101±4	16.2	13.6	152	152	100
10	14.4±0.5	96±4	16.0	13.4	153	153	100
37	13.8±0.7	92±5	16.3	12.3	154	154	100
75	14.2±0.8	95±5	17.0	12.7	154	154	100

[c]Acceptable Range = 12 to 18 CFM.

TABLE 6. Gallium Arsenide Inhalation Developmental Toxicity Study. Summation of Chamber Environmental Data for Mice.

TEMPERATURE (°F)[a]

Target Concentration (mg/m^3)	Mean±SD	Percent of Target±%RSD	Maximum	Minimum	Number of Samples	Number of Samples In Range	Percent of Samples In Range
Room	71.0±3.1	99±4	78.2	63.4	176	103	58
0	75.6±1.3	101±2	78.2	71.7	166	163	98
1	76.1±1.1	101±1	78.8	73.2	81	77	95
10	75.0±1.6	100±2	78.3	71.5	166	160	96
37	75.3±1.8	100±2	80.0	71.4	168	150	89
75	74.7±1.6	100±2	78.7	71.7	157	151	96

[a]Acceptable Range = 72 to 78°F for the exposure chambers and 69 to 75°F for the exposure room.

RELATIVE HUMIDITY (%RH)[b]

Target Concentration (mg/m^3)	Mean±SD	Percent of Target±%RSD	Maximum	Minimum	Number of Samples	Number of Samples In Range	Percent of Samples In Range
0	57.0±5.9	104±10	69	42	169	169	100
1	50.7±4.2	92±8	62	42	84	84	100
10	58.1±4.9	106±8	71	48	170	169	99
37	56.3±7.4	102±13	68	39	171	166	97
75	55.4±7.8	101±14	68	38	171	165	96

[b]Acceptable Range = 40 to 70%.

AIRFLOW (CFM)[c]

Target Concentration (mg/m^3)	Mean±SD	Percent of Target±%RSD	Maximum	Minimum	Number of Samples	Number of Samples In Range	Percent of Samples In Range
0	15.2±0.7	101±5	16.2	13.6	182	182	100
1	14.5±0.7	96±5	16.1	12.9	92	92	100
10	14.4±0.5	96±4	16.0	13.3	183	183	100
37	13.8±0.7	92±5	16.3	12.3	184	184	100
75	14.2±0.8	95±5	17.0	12.7	184	184	100

[c]Acceptable Range = 12 to 18 CFM.

TABLE 7. Gallium Arsenide Inhalation Developmental Toxicity Study: Minimum Detectable Limits (MDL) for Gallium, Arsenic and Zinc.

Tissue Type	MDL Ga (µg)	MDL As (µg)	MDL Zn (µg)
Female Rat/Whole Blood	0.06	1.26	--[a]
Male Rat/Whole Blood	0.05	0.52	--[a]
Rat/Fetal Tissue	0.06	0.01	--[a]
Rat/Uterine Contents	0.43	0.47	--[a]
Rat and Mouse/Testes	0.10	0.15	0.25

[a] Zinc was only measured in testes.

TABLE 8. Gallium Arsenide Inhalation Developmental Toxicity Study: Minimum Quantifiable Limits (MQL) for Gallium, Arsenic and Zinc.

Tissue Type	MQL Ga (µg)	MQL As (µg)	MQL Zn (µg)
Female Rat/Whole Blood	0.20	4.22	--[a]
Male Rat/Whole Blood	0.15	1.66	--[a]
Rat/Fetal Tissue	0.2	0.02	--[a]
Rat/Uterine Contents	1.22	1.48	--[a]
Rat and Mouse/Testes	0.29	0.45	0.97

[a] Zinc was only measured in testes.

TABLE 9. Gallium Arsenide Inhalation Developmental Toxicity Study: Summation of Exposure Concentration Data.

RATS

Target Conc. (mg/m^3)[a]	Mean±SD	Percent of Target±%RSD	Maximum	Minimum	Number of Samples	Number Samples In Range	Percent of Samples In Range
Room[b]	0.029±0.018	—	0.180	0.001	287	—	—
0[c]	0.010±0.003[d]	—	0.024	0.0	287	—	—
10	10.2±0.74	102±7	15.1	8.7	185	182	98
37	38.8±12.3	105±32	166	28.8	186	175	94
75	75.6±6.72	101±9	105	60.4	185	180	97

MICE

Target Conc. (mg/m^3)[a]	Mean±SD	Percent of Target±%RSD	Maximum	Minimum	Number of Samples	Number of Samples In Range	Percent of Samples In Range
Room[b]	0.028±0.018	—	0.180	0.001	336	—	—
0[c]	0.009±0.003[d]	—	0.024	0.0	336	—	—
1	1.0±0.09	100±9	1.5	0.86	119	117	98
10	10.1±0.74	102±7	15.1	8.3	224	220	98
37	38.3±11.3	104±30	166	25.9	225	211	94
75	75.3±6.53	100±9	105	60.4	224	219	98

[a] Acceptable Range = Target ± 20%.

[b] The MDL for the RAM monitoring the exposure room was 0.013 mg/m^3.

[c] The MDL for the RAM monitoring the control chamber was 0.006 mg/m^3.

[d] The MDL for the RAM monitoring the control chamber was determined to be 0.006 mg/m^3 prior to the exposures. During the study, however, the zero offset for the instrument drifted on several occasions, resulting in values above the MDL. The absence of gallium arsenide aerosol had been verified by filter sample analysis. Therefore we believe the value of 0.009 mg/m^3 to be consistent with values <MDL.

TABLE 10. Gallium Arsenide Inhalation Developmental Toxicity Study: Female Rat Disposition.

Target Gallium Arsenide Conc. (mg/m^3)	Treatment Group	Virgins	Mated	Mated Distribution	Removed	Scheduled Sacrifice
0	1	10	30	9	0	49
10	2	10	31	9	0	50
37	3	10	31	9	1[a]	49
75	4	10	30	9	0	49

[a]Animal removed from study due to bad teeth.

TABLE 11. Gallium Arsenide Inhalation Developmental Toxicity Study: Mean Body, Uterine, Adjusted Maternal Gain[a] and Organ Weights of Pregnant Developmental Toxicology Rats (g ± SD).

Target Gallium Arsenide Concentration (mg/m^3)	0	10	37	75
N	25	27	28	28
Body Weight				
0 dg	286.1 ± 19.3	286.3 ± 18.7	286.1 ± 18.3	284.0 ± 16.3
4 dg	313.2 ± 21.3	313.1 ± 22.3	311.8 ± 18.3	313.5 ± 19.4
6 dg	316.3 ± 22.6	316.1 ± 23.2	317.3 ± 19.9	317.8 ± 19.1
10 dg	332.6 ± 23.0	329.2 ± 26.5	331.9 ± 22.3	331.5 ± 20.4
14 dg	353.2 ± 25.9	353.7 ± 26.1	355.3 ± 22.2	351.9 ± 23.0
17 dg	380.4 ± 27.2	378.3 ± 30.5	382.7 ± 24.7	377.6 ± 27.2
20 dg	420.9 ± 35.4	419.8 ± 39.5	427.1 ± 26.9	419.5 ± 33.0
Adjusted Maternal Gain[a]	54.7 ± 20.1	54.3 ± 19.4	61.6 ± 11.6	63.1 ± 18.5
Uterine	80.1 ± 18.0	79.3 ± 18.3	79.4 ± 12.3	72.4 ± 23.3
Liver	17.3 ± 2.1	17.5 ± 1.8	17.8 ± 1.8	17.5 ± 2.0
Percent LBWR[b]	4.11 ± 0.30	4.18 ± 0.33	4.17 ± 0.29	4.18 ± 0.29
Kidney	2.32 ± 0.21	2.34 ± 0.23	2.37 ± 0.21	2.38 ± 0.28
Percent KBWR[c]	0.55 ± 0.06	0.56 ± 0.06	0.56 ± 0.04	0.57 ± 0.07

[a] Adjusted maternal gain = weight (20 dg) - weight (0 dg) - uterine weight.
[b] LBWR = liver to body weight ratio x 100.
[c] KBWR = kidney to body weight ratio x 100.

TABLE 12. Gallium Arsenide Inhalation Developmental Toxicity Study: Mean Body and Organ Weights of Virgin Rats (g ± SD).

Target Gallium Arsenide Concentration (mg/m^3)	0	10	37	75
N	10	10	10	10
Body Weight				
Exposure Day 1	299.7 ± 23.3	303.3 ± 26.6	305.8 ± 31.1	305.3 ± 28.0
Exposure Day 3	305.3 ± 22.8	304.2 ± 23.2	304.8 ± 30.4	301.5 ± 26.8
Exposure Day 7	313.1 ± 27.1	308.8 ± 23.5	305.3 ± 30.4	304.8 ± 25.0
Exposure Day 11	317.3 ± 27.1	315.1 ± 29.3	314.5 ± 32.0	310.5 ± 25.5
Exposure Day 14	316.2 ± 26.9	319.6 ± 31.5	319.4 ± 30.4	312.6 ± 22.1
Sacrifice	316.6 ± 27.5	321.4 ± 31.2	323.5 ± 32.9	314.7 ± 23.8
Liver[a]	13.23 ± 1.35	15.45 ± 2.31[b]	16.03 ± 1.58[b]	14.47 ± 1.82
Percent LBWR[c]	4.18 ± 0.28	4.79 ± 0.43	4.96 ± 0.11	4.60 ± 0.44
Kidney	2.43 ± 0.24	2.54 ± 0.29	2.63 ± 0.30	2.54 ± 0.22
Percent KBWR[d]	0.77 ± 0.06	0.79 ± 0.05	0.81 ± 0.05	0.81 ± 0.07

[a] Significantly correlated with exposure concentration, $p<0.05$.
[b] Significantly different from control group, $p<0.05$.
[c] LBWR = liver to body weight ratio x 100.
[d] KBWR = kidney to body weight ratio x 100.

TABLE 13. Gallium Arsenide Inhalation Developmental Toxicity Study: Reproductive Measures (Mean ± SD) in Rats.

Target Gallium Arsenide Concentration (mg/m^3)	0	10	37	75
NUMBER OF:				
Sperm-positive Surviving Females	30	31	30	30
Number Pregnant	25	27	28	28
Pregnancies Examined	25	27	28	28
Corpora Lutea/Dam	17.3 ± 1.8	17.6 ± 1.9	17.6 ± 2.0	18.5 ± 3.4
Implantations/Dam	15.6 ± 3.2	15.6 ± 3.6	16.0 ± 2.4	15.2 ± 5.3
Live Fetuses/Litter	14.7 ± 3.5	15.0 ± 3.5	14.9 ± 2.4	14.4 ± 5.1
Resorptions/Litter:	0.8 ± 0.9	0.6 ± 0.8	1.0 ± 0.8	0.8 ± 1.1
Early	0.4 ± 0.6	0.4 ± 0.8	0.8 ± 0.8	0.5 ± 0.8
Late	0.4 ± 0.7	0.2 ± 0.4	0.3 ± 0.6	0.3 ± 0.7
Dead Fetuses/Litter	0	0	0	0
Litters with Resorptions	15	12	21	14
Litters with ≥2 Resorptions	4	4	6	6
PERCENTAGE OF:				
Pregnant Females	83	87	93	93
Live Fetuses/Litter	93.7 ± 7.2	96.2 ± 5.1	93.5 ± 5.1	94.5 ± 7.2
Resorptions/Litter:	6.3 ± 7.2	3.8 ± 5.1	6.5 ± 5.1	5.5 ± 7.2
Early	2.5 ± 3.6	2.7 ± 5.0	4.8 ± 5.1	3.1 ± 4.4
Late	3.8 ± 6.9	1.1 ± 2.3	1.7 ± 4.0	2.4 ± 5.8
Dead Fetuses/Litter	0	0	0	0
Litters with Resorptions	60	44	75	50
Litters with ≥2 Resorptions	16	15	21	21

TABLE 14. Gallium Arsenide Inhalation Developmental Toxicity Study: Average Fetal Weights, Average Fetal Liver Weights (Mean of Litter Means; g ± SD), and Fetal Sex Ratio in Rats (Mean of Litter Means; % ± SD).

Target Gallium Arsenide Concentration (mg/m^3)	0	10	37	75
Litters Examined with Live Fetuses	25	27	28	28
Fetal Weight				
Male[a]	3.70 ± 0.24	3.59 ± 0.23	3.56 ± 0.21	3.3[illegible] ± 0.32[b]
Female[a]	3.57 ± 0.27	3.42 ± 0.24	3.39 ± 0.18[b]	3.20 ± 0.30[b]
Fetal Liver Wt.				
Male	0.313 ± 0.033	0.302 ± 0.031	0.309 ± 0.032	0.296 ± 0.046
Female	0.308 ± 0.031	0.289 ± 0.035	0.300 ± 0.027	0.288 ± 0.049
% Fetal LBWR[c]				
Male	8.46 ± 0.85	8.44 ± 0.66	8.68 ± 0.67	8.84 ± 0.76
Female	8.62 ± 0.68	8.44 ± 0.73	8.86 ± 0.60	8.96 ± 1.07
% Male Fetuses	51 ± 18	54 ± 15	53 ± 13	46 ± 18

[a] Significantly correlated with exposure concentration, $p<0.05$.
[b] Significantly different from controls, $p<0.05$.
[c] LBWR = liver to body weight ratio x 100.

TABLE 15. Gallium Arsenide Inhalation Developmental Toxicity Study: Malformations Observed in Live Rat Fetuses.

Target Gallium Arsenide Concentration (mg/m^3)		Fetuses[a] 0	10	37	75	Litters[a] 0	10	37	75
Total Examined[b]		368	405	418	403	25	27	28	28
Heads examined[c]		185	205	209	201	25	27	28	27
Skulls examined[d]		183	200	209	202	25	27	28	28
Viscera examined[e]		183	200	209	202	25	27	28	28
Malformations:									
Cleft Palate	No.	–	1	–	1	–	1	–	1
	(%)		(0.2)		(0.2)		(3.7)		(3.6)
Edema	No.	–	–	–	1	–	–	–	1
	(%)				(0.2)				(3.6)
TOTAL:									
Malformations	No.	0	1	0	2	–	–	–	–
Fetuses (Litters) with Malformations	No.	0	1	0	2	0	1	0	2
	(%)	(0.0)	(0.2)	(0.0)	(0.5)	(0.0)	(3.7)	(0.0)	(7.1)

[a] A single fetus or litter may be represented more than once in this table.
[b] All fetuses examined for external and skeletal defects. One-half had heads removed prior to skeletal staining.
[c] Heads fixed in Bouin's solution for evaluation of soft-tissue craniofacial evaluations.
[d] Heads remained on the fetuses for skeletal examination; see (b).
[e] Visceral examinations performed on approx. 50% of live fetuses.

TABLE 16. Gallium Arsenide Inhalation Developmental Toxicity Study. Mean Percent of Live Rat Fetuses Affected per Litter (Mean Percent ± SD).

Target Gallium Arsenide Concentration (mg/m^3)	0	10	37	75
Number Litters with Live Fetuses	25	27	28	28
Live Fetuses/Litter	14.7 ± 3.5	15.0 ± 3.5	14.9 ± 2.4	14.4 ± 5.1
MALFORMATIONS:				
Cleft Palate	–	0.3 ± 1.5	–	0.2 ± 1.0
Edema	–	–	–	3.6 ± 18.9
Total Malformations	–	0.3 ± 1.5	–	3.8 ± 18.9
VARIATIONS:				
Dilated Ureter	7.0 ± 13.8	8.0 ± 16.1	8.9 ± 21.2	3.6 ± 10.1
Renal Pelvic Cavitation	2.6 ± 7.3	3.1 ± 11.4	0.7 ± 3.8	0.4 ± 2.1
Missing Innominate Artery	–	–	–	0.4 ± 2.4
Misaligned Sternebrae	0.1 ± 1.8	2.6 ± 5.3	2.2 ± 3.9	2.0 ± 4.2
Sternebral Defects[a]	0.3 ± 1.4	0.2 ± 1.0	0.9 ± 2.3	0.7 ± 2.9
Rib Defects[a]	1.0 ± 2.9	0.3 ± 1.4	0.6 ± 2.5	1.2 ± 4.0
Supernumerary Rib	8.4 ± 9.8	5.2 ± 6.6	6.7 ± 9.5	6.3 ± 11.8
Reduced Ossification:				
Pelvis	2.7 ± 7.0	2.5 ± 7.2	0.9 ± 2.7	0.5 ± 10.9
Phalanges	1.9 ± 6.8	0.8 ± 2.3	0.7 ± 2.7	3.6 ± 9.4
Skull	8.5 ± 16.6	10.6 ± 22.8	2.2 ± 5.9	8.5 ± 14.2
Sternebrae[b]	6.8 ± 9.2	15.8 ± 19.0	24.7 ± 23.4[c]	30.3 ± 25.4[c]
Vertebral centra	17.4 ± 20.0	22.2 ± 21.7	22.1 ± 17.2	27.0 ± 24.5
Total Variations[b]	35.8 ± 21.0	43.1 ± 21.1	48.8 ± 25.1	56.1 ± 27.6[c]

[a] See text for description of sternebral and rib defect.
[b] Significantly correlated with exposure concentration, $p<0.05$.
[c] Significantly different than controls after arc sine transformation, $p<0.05$.

TABLE 17. Gallium Arsenide Inhalation Developmental Toxicity Study: Variations and Reduced Ossifications Observed in Live Rat Fetuses.

Target Gallium Arsenide Exposure Concentration (mg/m^3)		Fetuses [a] 0	10	37	75	Litters [a] 0	10	37	75
Total Examined[b]		368	405	418	403	25	27	28	28
Heads examined[c]		185	205	209	201	25	27	28	27
Skulls examined[d]		183	200	209	202	25	27	28	28
Viscera examined[e]		183	200	209	202	25	27	28	28
VARIATIONS:									
Dilated Ureter	No.	13	11	16	7	7	9	8	5
	(%)	(7.1)	(5.5)	(7.7)	(3.5)	(28.0)	(33.3)	(28.6)	(17.9)
Renal Pelvic	No.	5	2	1	1	3	2	1	1
Cavitation	(%)	(2.7)	(1.0)	(0.5)	(0.5)	(12.0)	(7.4)	(3.6)	(3.6)
Missing	No.	–	–	–	1	–	–	–	1
Innominate Artery	(%)				(0.5)				(3.6)
Misaligned	No.	2	11	9	8	2	8	8	7
Sternebrae	(%)	(0.5)	(2.7)	(2.2)	(2.0)	(8.0)	(29.6)	(28.6)	(25.0)
Sternebral Defects[f]	No.	1	1	4	4	1	1	4	2
	(%)	(0.3)	(0.2)	(1.0)	(1.0)	(4.0)	(3.7)	(14.3)	(7.1)
Rib Defects[f]	No.	4	1	3	5	3	1	2	3
	(%)	(1.1)	(0.2)	(0.7)	(1.2)	(12.0)	(3.7)	(7.1)	(10.7)
Supernumerary Rib	No.	30	23	30	23	15	14	14	13
	(%)	(8.2)	(5.7)	(7.2)	(5.7)	(60.0)	(51.9)	(50.0)	(46.4)
REDUCED OSSIFICATIONS:									
Pelvis	No.	6	9	4	24	6	4	3	6
	(%)	(1.6)	(2.2)	(1.0)	(6.0)	(24.0)	(14.8)	(10.7)	(21.4)
Phalanges	No.	3	3	3	17	3	3	2	5
	(%)	(0.8)	(0.7)	(0.7)	(4.2)	(12.0)	(11.1)	(7.1)	(17.9)
Skull	No.	17	17	5	19	6	9	4	10
	(%)	(9.3)	(8.5)	(2.4)	(9.4)	(24.0)	(33.3)	(14.3)	(35.7)
Sternebrae	No.	22	62	106	142	15	17	23	23
	(%)	(6.0)	(15.3)	(25.4)	(35.2)	(60.0)	(63.0)	(82.1)	(82.1)
Vertebral centra	No.	58	91	97	105	19	20	23	25
	(%)	(15.8)	(22.5)	(23.2)	(26.1)	(76.0)	(74.1)	(82.1)	(89.3)
Total Number of Variations[g]	No.	161	231	278	356	–	–	–	–
Total Fetuses (Litters) with Variations	No.	123	175	207	239	25	27	27	26
	(%)	(33.4)	(43.2)	(49.5)	(59.3)	(100.0)	(100.0)	(96.4)	(92.9)

[a]A single fetus or litter may be represented more than once in this table.
[b]All fetuses were examined for external and skeletal defects. One-half had heads removed prior to skeletal staining.
[c]Heads were fixed in Bouin's solution for soft-tissue craniofacial evaluations.
[d]Heads remained on the fetuses for skeletal examination; see (b).
[e]Viscerals were performed on approx. 50% of live fetuses.
[f]See text for description of sternebral and rib defects.
[g]There may be >1 variation per fetus.

TABLE 18. Gallium Arsenide Inhalation Developmental Toxicity Study: Female Mouse Disposition.

Target Gallium Arsenide Conc. (mg/m^3)	Treatment Group	Virgins	Mated	Virgins Died[a]	Mated Died[a]	Scheduled Sacrifice
0	1	10	23	0	0	33
10	2	10	24	0	0	34
37	3	10	22	8	5	19
75	4	10	24	8	8	18

[a]Moribund sacrifice or found dead.

TABLE 19. Gallium Arsenide Inhalation Developmental Toxicity Study: Mean Body, Uterine, Adjusted Maternal Gain, and Organ Weights of Surviving Pregnant Mice (g ± SD).

Target Gallium Arsenide Concentration (mg/m^3)	0	10	37	75
N	17	22	16	14
Body Weight				
0 dg	29.4 ± 1.4	29.2 ± 1.7	29.1 ± 1.8	29.6 ± 1.3
4 dg	30.1 ± 1.7	30.1 ± 1.7	29.8 ± 1.8	30.3 ± 1.7
6 dg	30.6 ± 1.7	31.2 ± 2.0	30.5 ± 1.7	30.6 ± 1.7
9 dg[a]	32.5 ± 1.6	31.1 ± 2.4	28.8 ± 2.8[b]	27.7 ± 2.6[b]
12 dg[a]	38.0 ± 2.7	35.9 ± 3.6	32.8 ± 3.9[b]	30.8 ± 4.6[b]
15 dg[a]	45.7 ± 4.1	43.7 ± 5.8	39.7 ± 6.2[b]	36.1 ± 8.0[b]
18 dg[a]	54.8 ± 5.8	52.9 ± 8.8	47.2 ± 10.4	40.4 ± 12.6[b]
Adjusted Maternal Gain[a,c]	5.5 ± 1.8	5.8 ± 2.4	4.3 ± 2.7	2.4 ± 3.2[b]
Uterine[a]	19.9 ± 4.4	17.9 ± 6.4	13.8 ± 8.3	8.5 ± 9.6[b]
Liver	2.79 ± 0.33	2.80 ± 0.44	2.58 ± 0.73	2.36 ± 0.60
Percent LBWR[a,d]	5.12 ± 0.52	5.34 ± 0.48	5.56 ± 1.37	5.93 ± 0.61[b]
Kidney	0.45 ± 0.05	0.47 ± 0.07	0.60 ± 0.57	0.46 ± 0.05
Percent KBWR[e]	0.83 ± 0.11	0.91 ± 0.22	1.32 ± 1.15	1.23 ± 0.38

[a]Significantly correlated with exposure concentration, $p<0.05$.
[b]Significantly different from control group, $p<0.05$.
[c]Adjusted maternal gain = weight (18 dg) - weight (0 dg) - uterine weight.
[d]LBWR = liver to body weight ratio x 100.
[e]KBWR = kidney to body weight ratio x 100.

TABLE 20. Gallium Arsenide Inhalation Developmental Toxicity Study: Mean Body and Organ Weights of Virgin Mice (g ± SD).

Target Gallium Arsenide Concentration (mg/m^3)	0	10	37	75
N	10	10	2	2
Body Weight				
Exposure Day 1	29.5 ± 2.0	28.9 ± 1.6	30.2 ± 1.1	28.9 ± 2.1
Exposure Day 3	29.2 ± 1.9	30.1 ± 2.0	29.9 ± 2.5	29.1 ± 2.6
Exposure Day 6	29.6 ± 2.1	27.2 ± 2.2	26.9 ± 2.6	26.7 ± 1.0
Exposure Day 9	31.8 ± 2.7	26.4 ± 2.2	29.0 ± 1.6	26.9 ± 2.5
Exposure Day 12	30.4 ± 2.1	28.2 ± 2.0	29.1 ± 1.1	27.7 ± 1.5
Sacrifice	29.2 ± 1.9	28.7 ± 1.8	30.0 ± 1.3	28.7 ± 1.9
Liver[a]	1.72 ± 0.16	1.78 ± 0.18	1.85 ± 0.22	1.98 ± 0.54[b]
Percent LBWR[c]	5.89 ± 0.37	6.20 ± 0.41	6.17 ± 1.01	6.86 ± 1.41
Kidney	0.42 ± 0.04	0.41 ± 0.04	0.44 ± 0.03	0.46 ± 0.04
Percent KBWR[d]	1.45 ± 0.11	1.41 ± 0.10	1.47 ± 0.17	1.59 ± 0.02

[a]Significantly correlated with exposure concentration, $p<0.05$.
[b]Significantly different from control group, $p<0.05$.
[c]LBWR = liver to body weight ratio x 100.
[d]KBWR = kidney to body weight ratio x 100.

TABLE 21. Gallium Arsenide Inhalation Developmental Toxicity Study: Reproductive Measures in Mice (Means of Litter Means ± SD).

Target Gallium Arsenide Concentration (mg/m^3)	0	10	37	75
NUMBER OF:				
Surviving Females	23	24	17	16
Number Pregnant	17	22	16	14
Pregnancies Examined	17	22	16	14
Corpora Lutea/Dam[a]	13.6 ± 1.9	12.5 ± 4.7	10.8 ± 5.7	7.3 ± 7.6[b]
Implantations/Dam	12.8 ± 3.1	12.6 ± 3.1	12.3 ± 3.0	12.4 ± 2.9
Live Fetuses/Litter[a]	11.9 ± 3.0	11.0 ± 4.1	9.1 ± 5.7	5.6 ± 6.8[b]
Resorptions/Litter[a]	0.9 ± 0.9	1.6 ± 1.8	3.2 ± 4.8	6.9 ± 5.7[b]
Early[a]	0.6 ± 0.8	1.2 ± 1.9	2.1 ± 4.4	5.7 ± 5.7[b]
Late	0.3 ± 0.5	0.4 ± 0.7	1.1 ± 2.6	1.1 ± 3.7
Dead Fetuses/Litter	0	0	0	0
Litters with Resorptions	9	18	10	11
Litters with ≥2 Resorptions	6	10	6	10
Litters with 100% Non-live Fetuses	0	2	4	8[c]
PERCENTAGE OF:				
Pregnant	74	92	94	88
Live Fetuses/Litter[a]	93.4 ± 7.1	82.6 ± 27.3	70.2 ± 42.5	39.3 ± 47.6[b]
Resorptions/Litter[a]	6.6 ± 7.1	17.4 ± 27.3	29.8 ± 42.5	60.8 ± 47.6[b]
Early[a]	4.4 ± 6.1	14.5 ± 28.3	20.8 ± 39.6	52.6 ± 49.8[b]
Late	2.2 ± 3.5	2.9 ± 4.8	9.1 ± 21.4	8.2 ± 26.6
Dead Fetuses/Litter	0	0	0	0
Litters with Resorptions	53	82	63	79
Litters with ≥2 Resorptions	35	45	38	71
Litters with 100% Non-live Fetuses	0	9	25	57[c]

[a]Significantly correlated with exposure concentration, $p<0.05$.
[b]Significantly different from control group, $p<0.05$.
[c]Significantly greater than control group (Chi-square, $p<0.05$).

TABLE 22. Gallium Arsenide Inhalation Developmental Toxicity Study: Average Fetal Weights (Mean of Litter Means; g ± SD) and Fetal Sex Ratio in Mice (Mean of Litter Means; % ± SD).

Target Gallium Arsenide Concentration (mg/m^3)	0	10	37	75
Litters Examined with Live Fetuses	17	20	12	6
Fetal Weight[a]				
Male[a]	1.34 ± 0.09	1.27 ± 0.11	1.16 ± 0.05[b]	1.12 ± 0.07[b]
Female[a]	1.33 ± 0.10	1.25 ± 0.11	1.13 ± 0.09[b]	1.08 ± 0.10[b]
Percent Male	43 ± 16	52 ± 15	51 ± 11	45 ± 13

[a]Significantly correlated with exposure concentration, $p<0.05$.
[b]Significantly different from the control group, $p<0.05$.

TABLE 23. Gallium Arsenide Inhalation Developmental Toxicity Study: Malformations Observed in Live Mouse Fetuses.

Target Gallium Arsenide Concentration (mg/m^3)		Fetuses[a] 0	10	37	75	Litters[a] 0	10	37	75
Total Examined[b]		202	242	145	78	17	20	12	6
Heads Examined[c]		102	121	75	41	17	20	12	6
Skulls Examined[d]		100	121	70	37	17	20	12	6
Viscera Examined[e]		100	121	70	37	17	20	12	6
Malformations:									
Cleft Palate	No.	–	1	2	2[f]	–	1	2	1
	(%)		(0.4)	(1.4)	(2.6)		(5.0)	(16.7)	(16.7)
Exencephaly	No.	–	1	–	–	–	1	–	–
	(%)		(0.4)				(5.0)		
Limb Flexure	No.	2	4	1	–	2	4	1	–
	(%)	(1.0)	(1.7)	(0.7)		(11.8)	(20.0)	(8.3)	
Open Eye	No.	1	–	–	–	1	–	–	–
	(%)	(0.5)				(5.9)			
Vertebral Defects[g]	No.	–	–	3	3[f]	–	–	3	2[f]
	(%)			(2.1)	(3.8)			(25.0)	(33.3)
TOTAL: Malformations	No.	3	6	6	5	–	–	–	–
Fetuses (Litters) with Malformations	No.	3	6	6	5	3	5	6	2
	(%)	(1.5)	(2.5)	(4.1)	(6.4)	(17.6)	(25.0)	(50.0)	(33.3)

[a]A single fetus or litter may be represented more than once in this table.
[b]All fetuses examined for external and skeletal defects. One-half had heads removed prior to skeletal staining.
[c]Heads fixed in Bouin's solution for soft-tissue craniofacial evaluations.
[d]Heads that remained on the fetuses had a skeletal examination; see (b).
[e]Viscerals performed on approximately 50% of live fetuses.
[f]Significantly greater than control group (Chi-square, $p<0.05$).
[g]See text for description of vertebral defects.

TABLE 24. Gallium Arsenide Inhalation Developmental Toxicity Study: Mean Percent of Live Mouse Fetuses Affected per Litter (Mean Percent ± SD).

Target Gallium Arsenide Concentration (mg/m^3)	0	10	37	75
Number Litters Examined	17	20	12	6
Live Fetuses/Litter	11.9 ± 3.0	11.0 ± 4.1	9.1 ± 5.7	5.6 ± 6.8
MALFORMATIONS:				
Cleft Palate	–	0.5 ± 2.2	1.3 ± 3.1	2.8 ± 6.8
Encephalocele	–	0.4 ± 1.7	–	–
Limb Flexure	1.0 ± 2.9	1.7 ± 3.7	0.6 ± 2.2	–
Open Eye	0.4 ± 1.7	–	–	–
Vertebral Defects[a]	–	–	2.2 ± 4.1	4.2 ± 7.0
Total Malformations	1.4 ± 3.2	2.6 ± 5.3	4.2 ± 4.4	6.9 ± 11.1
VARIATIONS:				
Misaligned Sternebrae	16.6 ± 15.6	14.6 ± 13.7	24.8 ± 19.7	34.0 ± 13.2
Sternebral Defects[a,b]	3.8 ± 5.8	9.1 ± 13.4	10.0 ± 11.7	23.3 ± 27.8[c]
Rib Defects[a]	–	–	2.7 ± 5.2	3.1 ± 4.8
Supernumerary Rib	26.6 ± 26.2	15.7 ± 21.8	23.2 ± 23.2	30.0 ± 31.8
REDUCED OSSIFICATIONS:				
Pelvis	–	–	1.4 ± 4.8	–
Phalanges	–	–	4.2 ± 14.4	–
Ribs	–	–	2.8 ± 9.6	–
Sternebrae[b]	2.5 ± 4.3	8.3 ± 10.9	18.1 ± 17.1[c]	29.7 ± 25.2[c]
Skull	2.5 ± 10.4	4.5 ± 12.4	7.2 ± 15.2	2.4 ± 5.8
Vertebrae	0.4 ± 1.6	–	1.4 ± 4.8	5.6 ± 13.6
Total Variations[b]	41.7± 23.8	40.8 ± 23.8	56.3 ± 22.9	69.9 ± 24.4

[a]See text for description of sternebral, rib, and vertebral defects.
[b]Significantly correlated with exposure concentration, $p<0.05$.
[c]Significantly different than controls after arc sine transformation, $p<0.05$.

TABLE 25. Gallium Arsenide Inhalation Developmental Toxicity Study: Variations and Reduced Ossifications Observed in Live Mouse Fetuses.

Target Gallium Arsenide Concentration (mg/m^3)		Fetuses[a] 0	10	37	75	Litters[a] 0	10	37	75
Total Examined[b]		202	242	145	78	17	20	12	6
Heads Examined[c]		102	121	75	41	17	20	12	6
Skulls Examined[d]		100	121	70	37	17	20	12	6
Viscera Examined[e]		100	121	70	37	17	20	12	6
VARIATIONS:									
Misaligned Sternebrae	No.	35	36	37	26[f]	12	16	11	6
	(%)	(17.3)	(14.9)	(25.5)	(33.3)	(70.6)	(80.0)	(91.7)	(100)
Sternebral Defects[g]	No.	8	24	14	17[f]	6	10	8	5
	(%)	(4.0)	(9.9)	(9.7)	(21.8)	(35.3)	(50.0)	(66.7)	(83.3)
Rib Defects[g]	No.	—	—	4	2	—	—	3	2
	(%)			(2.8)	(2.6)			(25.0)	(33.3)
Supernumerary Rib	No.	53	38	36	24	12	12	8	5
	(%)	(26.2)	(15.7)	(24.8)	(30.8)	(70.6)	(60.0)	(66.7)	(83.3)
REDUCED OSSIFICATIONS:									
Pelvis	No.	—	—	2	—	—	—	1	—
	(%)			(1.4)				(8.3)	
Phalanges	No.	—	—	6	—	—	—	1	—
	(%)			(4.1)				(8.3)	
Ribs	No.	—	—	4	—	—	—	1	—
	(%)			(2.8)				(8.3)	
Skull	No.	3	4	5	1	1	3	3	1
	(%)	(3.0)	(3.3)	(7.1)	(2.7)	(5.9)	(15.0)	(25.0)	(16.7)
Sternebrae	No.	6	21	27[f]	21[f]	5	12	10[f]	6[f]
	(%)	(3.0)	(8.7)	(18.6)	(26.9)	(29.4)	(60.0)	(83.3)	(100)
Vertebrae	No.	1	—	2	4	1	—	1	1
	(%)	(0.5)		(1.4)	(5.1)	(5.9)		(8.3)	(16.7)
TOTAL:									
Variations[h]	No.	106	123	137	95	—	—	—	—
Fetuses (Litters) with Variations	No.	84	100	84[f]	54[f]	16	20	12	6
	(%)	(41.6)	(41.3)	(57.9)	(69.2)	(94.1)	(100)	(100)	(100)

[a]A single fetus or litter may be represented more than once in this table.
[b]All fetuses examined for external and skeletal defects; one-half had heads removed prior to skeletal staining.
[c]Heads fixed in Bouin's solution for soft-tissue craniofacial evaluations.
[d]Heads that remained on the fetuses had a skeletal examination; see (b).
[e]Viscerals performed on approximately 50% of live fetuses.
[f]Significantly greater than control group (Chi-square, $p<0.05$).
[g]See text for description of sternebral and rib defects.
[h]There may be >1 variation per fetus.

TABLE 26. Inhalation Developmental Toxicity Study of Contemporary Control Data (N=157 Litters Mean ± SD) in Sprague-Dawley Rats.

	Number	Percent
Maternal Weight; 20 dg	399.2 ± 35.5	–
Gravid Uterine Weight	77.3 ± 17.2	–
Extra-gestational Weight Gain	49.7 ± 16.0	–
Implantations/Dam	15.2 ± 2.9	–
Live Fetuses/Litter	14.3 ± 3.1	93.5 ± 7.8
Resorptions/Litter	0.9 ± 1.0	6.5 ± 7.8
Early	0.7 ± 0.9	5.0 ± 7.2
Late	0.2 ± 0.5	1.4 ± 3.9
Dead Fetuses/Litter	0.0 ± 0.0	0.0 ± 0.0
Litters with Resorptions	89	56.7
Litters with ≥2 Resorptions	37	23.6
Fetal Weight	3.55 ± 0.3	–
Male	3.64 ± 0.4	–
Female	3.47 ± 0.3	–

TABLE 27. Inhalation Developmental Toxicity Study of Contemporary Control Data: Variations Observed in Live Sprague-Dawley Rat Fetuses.

		Fetuses[a] Number (Percent)	Litters[a] Number (Percent)	Mean Percent per Litter (± SD)
Total Examined[b]		2241	157	–
Heads Examined[c]		1129	157	–
Skulls Examined[d]		1112	157	–
Viscera Examined		1286	157	–
Variations:				
Dilated Ureter	No.	54	28	3.7 ± 9.9
	(%)	(4.2)	(17.8)	
Renal Pelvic Cavitation	No.	14	8	0.9 ± 4.0
	(%)	(1.1)	(5.1)	
Anomalous Rib	No.	1	1	0.0 ± 0.6
	(%)	(0.0)	(0.6)	
Rib Defect	No.	4	3	0.2 ± 1.2
	(%)	(0.2)	(1.9)	
Rudimentary Rib	No.	1	1	0.0 ± 0.5
	(%)	(0.0)	(0.6)	
Supernumerary Rib	No.	91	42	4.0 ± 8.6
	(%)	(4.1)	(26.8)	
Misaligned Sternebrae	No.	8	8	0.3 ± 1.5
	(%)	(0.4)	(5.1)	
Sternebral Defect	No.	1	1	0.0 ± 0.6
	(%)	(0.0)	(0.6)	
Missing Innominate Artery	No.	3	3	0.3 ± 2.0
	(%)	(0.2)	(1.9)	
Reduced Ossification:				
Pelvis	No.	41	25	2.3 ± 8.0
	(%)	(1.8)	(15.9)	
Phalanges	No.	16	12	1.0 ± 4.2
	(%)	(0.7)	(7.6)	
Skull	No.	37	14	2.7 ± 10.4
	(%)	(3.3)	(8.9)	
Sternebrae	No.	167	77	7.8 ± 12.8
	(%)	(7.4)	(49.0)	
Vertebrae	No.	124	58	5.7 ± 12.1
	(%)	(5.5)	(36.9)	
Total Variations	No.	562	–	26.3 ± 33.7
Total Fetuses (Litters) with Variations	No.	426	132	19.4 ± 19.0
	(%)	(19.0)	(84.1)	

[a] A single fetus or litter may be represented more than once in this table.
[b] All fetuses examined for external and skeletal defects. One-half had heads removed prior to skeletal staining.
[c] Heads fixed in Bouin's solution for soft-tissue craniofacial evaluations.
[d] Heads that remained on the fetuses had a skeletal examination; see (b).

TABLE 28. Inhalation Developmental Toxicity Study of Contemporary Control Data (N=184 Litters Mean ± SD) in Swiss CD-1 Mice.

	Number	Percent
Maternal Weight; 18 dg	54.4 ± 5.0	–
Gravid Uterine Weight	20.0 ± 3.7	–
Extra-gestational Weight Gain	6.6 ± 1.8	–
Implantations/Dam	12.5 ± 2.3	–
Live Fetuses/Litter	11.8 ± 2.3	94.2 ± 7.0
Resorptions/Litter	0.7 ± 0.9	5.8 ± 7.0
Early	0.5 ± 0.7	3.9 ± 6.0
Late	0.2 ± 0.5	1.9 ± 3.7
Dead Fetuses/Litter	0.0 ± 0.0	0.0 ± 0.0
Litters with Resorptions	95	51.6
Litters with ≥2 Resorptions	29	15.8
Fetal Weight	1.35 ± 0.1	–
Male	1.38 ± 0.1	–
Female	1.33 ± 0.1	–

TABLE 29. Inhalation Developmental Toxicity Study of Contemporary Control Data: Variations Observed in Live Swiss (CD-1) Mouse Fetuses.

		Fetuses[a] Number (Percent)	Litters[a] Number (Percent)	Mean Percent per Litter (± SD)
Total Examined[b]		2168	184	–
Heads Examined[c]		1086	184	–
Skulls Examined[d]		1082	184	–
Viscera Examined		1250	184	–
Variations:				
Dilated Ureter	No.	4	4	0.3 ± 2.3
	(%)	(0.3)	(2.2)	
Kinked Tail	No.	1	1	0.1 ± 1.1
	(%)	(0.0)	(0.5)	
Limb Flexure	No.	20	16	0.9 ± 3.1
	(%)	(0.9)	(8.7)	
Extra Ossification Sternebrae	No.	18	11	0.9 ± 5.2
	(%)	(0.8)	(6.0)	
Misaligned Sternebrae	No.	119	65	5.3 ± 9.4
	(%)	(5.5)	(35.3)	
Scrambled Sternebrae	No.	1	1	0.0 ± 0.5
	(%)	(0.0)	(0.5)	
Sternebral Defect	No.	8	6	0.3 ± 2.0
	(%)	(0.4)	(3.3)	
Rudimentary Rib	No.	1	1	0.1 ± 0.8
	(%)	(0.0)	(0.5)	
Supernumerary Rib	No.	395	119	18.7 ± 22.9
	(%)	(18.2)	(64.7)	
Reduced Ossification:				
Rib	No.	1	1	0.0 ± 0.6
	(%)	(0.0)	(0.5)	
Skull	No.	18	10	1.1 ± 5.4
	(%)	(1.7)	(5.4)	
Sternebrae	No.	69	48	3.2 ± 6.2
	(%)	(3.2)	(26.1)	
Vertebrae	No.	1	1	0.0 ± 0.5
	(%)	(0.0)	(0.5)	
Total Variations	No.	656	–	30.5 ± 27.3
Total Fetuses (Litters) with Variations	No.	589	159	27.5 ± 23.5
	(%)	(27.2)	(86.4)	

[a] A single fetus or litter may be represented more than once in this table.
[b] All fetuses examined for external and skeletal defects. One-half had heads removed prior to skeletal staining.
[c] Heads fixed in Bouin's solution for soft-tissue craniofacial evaluations.
[d] Heads that remained on the fetuses had a skeletal examination; see (b).

TABLE 30. Inhalation Developmental Toxicity Study of Contemporary Control Data: Malformations Observed in Live Swiss (CD-1) Mouse Fetuses.

		Fetuses[a] Number (Percent)	Litters[a] Number (Percent)	Mean Percent per Litter (± SD)
Total Examined[b]		2168	184	–
Heads Examined[c]		1086	184	–
Skulls Examined[d]		1082	184	–
Viscera Examined		1250	184	–
Malformations:				
Exencephaly	No.	1	1	0.1 ± 1.5
	(%)	(0.1)	(0.5)	
Folded Retina	No.	2	2	0.2 ± 1.9
	(%)	(0.2)	(1.1)	
Open Eye	No.	2	2	0.2 ± 1.6
	(%)	(0.2)	(1.1)	
Total Malformations	No.	5	–	0.3 ± 1.9
Total Fetuses (Litters) with Malformations	No.	4	4	0.2 ± 1.3
	(%)	(0.2)	(2.2)	

[a] A single fetus or litter may be represented more than once in this table.

[b] All fetuses examined for external and skeletal defects. One-half had heads removed prior to skeletal staining.

[c] Heads fixed in Bouin's solution for soft-tissue craniofacial evaluations.

[d] Heads that remained on the fetuses had a skeletal examination; see (b).

APPENDIX A

CHEMISTRY MONITORING NARRATIVE AND DATA

Narrative
MRI Chemical Analyses Report
Purity Analyses Summary
BNW Bulk Chemical Reanalyses Reports
Test Chemical Characterization, Storage, and Usage
Test Chemical Concentration Monitoring
Test Chemical Stability in the Exposure System

Narrative

I. NARRATIVE

A. Chemistry Materials and Methods

1. Bulk

a. Analysis at Chemistry Support Contract Laboratory

Chemical characterization of the gallium arsenide test material was presented in the October 26, 1988 report from Midwest Research Institute (MRI). Bulk chemical (MRI Lot No. M051988, Batch 06) was identified as gallium arsenide. Cumulative analytical data indicated a purity of greater than 98%.

Elemental analysis results showed good agreement of gallium with theoretical values. The elemental analysis results for arsenic were high; 52.8% compared to a theoretical value of 51.8% No organic impurities were found to be present by elemental analysis. Spark source mass spectrometry indicated that gallium and arsenic were the major components, and no impurities were present at concentrations greater than 100 ppm. All impurities totaled less than 170 ppm by spark source mass spectrometry. Weight loss upon drying indicated 0.04 ± 0.01% water. Chelometric titration indicated a purity of 99 ± 1%.

b. Reanalysis at Battelle Pacific Northwest Laboratories

The MRI recommended procedure was implemented and the bulk chemical purity was initially performed by elemental analysis. Subsequent chemical analyses were performed using chelometric titration. Chelometric titrations performed at BNW within 30 days of the projected start of the IRT study showed the test material relative purity was greater than 99%. Test material purity was acceptable for the study exposures.

c. Storage Recommendation for the Contract Laboratory

As recommended by the NTP analytical contractor, storage was at room temperature (~20 °C) under an inert nitrogen atmosphere. Test material was also protected from direct exposure to light. In order to provide more convenient containers for day to day usage of the bulk chemical, the test material was subdivided into 32 oz jars.

Additional details regarding test material receipt, usage, storage, and disposition may be found in the Test Chemical Characterization, Storage, and Usage Section of Appendix A.

2. Test Chemical Stability Studies

Test article stability in the exposure system was investigated prior to the start of the developomental toxicity study and during other prechronic toxicity studies conducted for the NTP (gallium arsenide repeated dose and subchronic studies). Additional investigations of test article stability were carried out during the first week of the developmental toxicity study. All test article stability studies accomplished to date, including those performed as part of the developmental toxicity study are summarized below.

Gallium arsenide undergoes oxidation in the presence of atmospheric oxygen. However, once a protective oxide surface layer is formed, further oxidation of the material is retarded. The extent of this oxidation was

examined in detail by x-ray photoelectron spectroscopy (XPS) during the gallium arsenide repeated dose study. These studies indicated that the surface of the test material contains gallium oxide, arsenic trioxide, and gallium arsenide. The molar ratio of gallium oxide to gallium arsenide in the surface oxide layer ranged from approximately 0.24 to 0.30, whereas the molar ratio of arsenic trioxide to gallium arsenide ranged approximately from 0.18 to 0.25. The XPS analysis indicated that the oxidation observed was confined to a surface layer depth of approximately 50 to 100 Å.

Although surface oxidation does occur in this test material, the relative amount of oxidized material is expected to be quite small, and confined to the outermost surface layers of the material. Any significant oxidation of the test material (more than 1-2%) would likely be detected using conventional x-ray powder diffraction analysis. However, in order to gain a more complete understanding of the nature and extent of this oxidation, additional analyses were performed prior to the subchronic study, with scanning transmission electron microscopy (STEM) in the transmission mode using the techniques of convergent beam electron diffraction (CBED) and selected area diffraction (SAD). These analyses showed a shell of polycrystalline material approximately 50Å in thickness around some of the gallium arsenide particles. This result is supported by previous analyses obtained with x-ray photoelectron spectroscopy, which indicated a surface layer containing significant quantities of gallium and arsenic oxides with a layer thickness of 50-100 Å. This result shows that the extent of oxidation is very small, and is further supported by oxygen measurements using XRF spectroscopy (thin window detector) as described below. TEM measurements were not repeated during the developmental toxicity study.

Prior to the subchronic study, the relative concentrations of oxygen, gallium and arsenic in the test material surface layer using energy dispersive x-ray fluorescence spectroscopy (XRF) with a thin-window detector. Although small amounts of oxygen were detected, this analysis indicated that the amount of oxygen in the test chemical was <0.5% relative to gallium arsenide. When repeated during the subchronic study, this analysis indicated the relative amounts of gallium (47.9 ± 1.2%) and arsenic (52.1 ± 1.2%) were quite near the theoretical gallium arsenide composition (48.2% Ga, 51.8% As). Oxygen was below the detection limit (<0.5%) for this method of analysis. These measurements were not repeated for the developmental toxicity study.

Test article stability was investigated using x-ray diffraction analysis (XRD) to determine the crystalline phases present in samples of gallium arsenide from the exposure system. XRD has a detection limit for various crystalline phases of 1-2% by volume, although this figure can vary somewhat depending on the amount of material available, sample preparation and analysis method, and interferences due to phase mixtures. XRD is useful in determining whether gross changes have occurred in the test material resulting from reaction with atmospheric gases such as carbon dioxide, oxygen, and water. XRD is also useful in detecting the introduction of metallic crystalline impurities that may be result from mechanical abrasion in the generation system.

Analysis of samples from occupied and unoccupied exposure chambers and from exposure generation system were completed as part of the NTP repeated dose and subchronic studies. Analysis of x-ray diffraction patterns of these samples indicated only the presence of gallium arsenide. No crystalline phases other than gallium arsenide were observed in any of the samples analyzed using this technique. Although other phases were likely present in the surface layer of the test material (gallium and arsenic oxides), the

relative amounts of these phases in the material were smaller than the detection limits for conventional x-ray diffraction analysis (1-2% by volume).

XRD analyses were repeated during the first week of the developmental toxicity study. The x-ray diffraction patterns of the chamber samples, generator reservoir samples, and bulk chemical were entirely consistent with the pattern expected from gallium arsenide (gallium arsenide, cubic). No indication of crystalline phases other than gallium arsenide was observed in any of the samples. No evidence of any oxidized phases such as Ga_2O_3 and As_2O_3 was observed. Thus, although these oxidized phases have previously been shown to be present using XPS and TEM analysis, their concentration is less than the XRD analysis detection limit of 1 to 2% by volume.

During previous studies, possible contamination of the test article by materials in the exposure generation system was investigated using x-ray fluorescence (XRF) spectroscopy and inductively coupled plasma-mass spectrometry (ICP-MS). This portion of the stability studies was designed to determine whether metallic impurities were introduced into the generated test atmosphere by the generation system. Gallium arsenide is expected to be quite stable within the generation system. However, small amounts of metallic impurities could be introduced into the system as a result of test chemical generation.

The generator contains a number of parts constructed of stainless steel and brass, and the liner on the trost mill is constructed of tungsten carbide. These metallic parts are all subject to abrasion by the mechanical action of the dust as it moves through the generator. Although significant contamination of the generated test article from these sources is not likely, analyses were conducted to demonstrate that such contamination does not occur. These analyses indicated that the relative amounts of Ga and As in the collected samples were very close to the theoretical amounts expected in gallium arsenide. During the repeated dose and subchronic studies minor amounts of metallic impurities were detected in samples from the exposure chambers, but these impurities were all present at very low concentrations (<1% by weight).

Analyses for metallic impurities in the exposure generation system were repeated using XRF analysis during the first week of the developmental toxicity study. Analyses for metallic impurities introduced by the test chemical generation system indicated the presence of minor amounts of iron, chromium, copper, and nickel . These impurities were observed in comparable amounts in the test material and were present at concentrations that were <1% by weight. Minor amounts of potassium, calcium, strontium, and silicon were also detected. These elements were observed only in the samples collected on filters, and are possibly a result of variability in the amount of these elements in the filters used for sample collection. Elevated values for potassium, calcium and silicon may also result from contamination of the chamber samples by ambient dust or animal food particles.

Additional details of test chemical stability measurements can be found in this Appendix.

3. Monitoring of Test Chemical Concentration in Exposure Chambers

Monitoring of gallium arsenide aerosol was accomplished with RAM-1 aerosol monitors. These devices use a pulsed light-emitting diode in combination with a silicon detector to sense the light scattered over a

forward angle of 45° to 95° by the particles traversing the sensing volume. The instrument responds to particles in the 0.1 to 20 μm diameter size range.

The sample system used a valve to multiplex one RAM monitor to two exposure chambers and either the control chamber or the room. The monitors were connected to the chambers through sample lines designed to minimize aerosol particle losses due to settling or impaction. The output of the RAM-1 monitors was automatically read and recorded by the Automated Data Acquisition and Control System. A Hewlett-Packard HP85B computer remotely controlled the selection of the correct sample stream and the acquisition of data from the monitor. The calibration equations contained in the HP85B were applied to the voltage data supplied by the RAM monitors. Each chamber concentration obtained was compared with limit values for the particular location. If a chamber concentration was beyond control limits, the HP85B computer would have immediately sent the information to the executive computer for appropriate action.

Exposure concentrations for the developmental toxicity study were initially set at 10.0, 37.0, and 75.0 mg/m^3. At the beginning of the study, two additional chambers were maintained at concentrations of 0.1 and 1.0 mg/m^3 for the purpose of chamber monitor calibration. These additional chambers were initially planned for use in providing a sufficient number of points for chamber monitor calibration curves, and were not to be used for animal exposures. However, due to unexpectedly high toxicity at the 75.0 mg/m^3 exposure concentration, the exposure concentration range for male mice was 1.0, 10.0, and 37.0 mg/m^3. Exposures of male mice began 12 days after female exposures started and continued for 12 days. Thus, exposure chambers were maintained at concentrations of 0.1, 1.0, 10.0, 37.0, and 75.0 mg/m^3, but the 0.1 mg/m^3 chamber was maintained only for calibration purposes.

The RAM aerosol monitors were calibrated against chamber concentrations determined from the analysis of filter samples obtained from the exposure chambers. The samples were collected on glass-fiber filters. Gallium arsenide was dissolved from the filters with 20% nitric acid, diluted, and analyzed for gallium using graphite furnace atomic absorption spectrophotometry (GFAAS).

The amount of gallium found by analysis of the filter samples was converted to the corresponding amount of gallium arsenide and divided by the sample volume to obtain the chamber concentration in mg/m^3. Chamber concentrations determined from analysis of filter grab samples were correlated with voltage readings from the RAMs obtained concurrently with grab samples. For each RAM, a least squares calibration curve was derived from chamber concentrations and the corresponding RAM voltage data. Either first- or second-order polynomials were used to construct the calibration equations. The form of the calibration curve employed was chosen to minimize errors in the prediction of chamber concentration from RAM voltage data.

Prior to the start of the developmental toxicity, several chemical specific calibrations of the RAM monitors were accomplished using GFAAS. These calibrations were conducted in animal occupied chambers during the final stages of the gallium arsenide subchronic study. Additional chemical specific calibrations were determined during the developmental toxicity study.

There was no on-line standard for gallium arsenide aerosol. To ensure that chamber concentrations were within 20% of the target exposure concentrations, filter grab samples were obtained daily from exposure chambers and the amount of gallium arsenide on each filter was determined gravimetrically. If the chamber concentration determined from the gravimetric

analysis was not within ±20% of the chamber target concentration, chemical specific recalibration using GFAAS was accomplished.

The RAM-1 monitors are not chemically specific for gallium arsenide. They respond to the presence of any particulate material within the correct size range which is sampled from the chamber. They were, however, calibrated by a method which possesses a very high chemical specificity. Experience in our laboratory indicates that the presence of animals contributes little or no measurable increase in the RAM readings at the chosen target exposure concentrations.

During prestart testing for the gallium arsenide the minimum detectable limit (MDL) was determined for each RAM monitor. (Note: Determinations of MDL, MQL, and MLQ were made during the prestart phase of the gallium arsenide subchronic study, which was accomplished immediately prior to the developmental toxicity study.) At the end of a generation day, the chamber concentration was allowed to decay to zero in all chambers. During chamber decay, test material concentration in the high chamber was measured using the RAM employed to monitor the low chamber (RAM#3), until a steady state concentration near zero was achieved. At this point, all three RAMs were allowed to execute their normal duty cycle, thereby measuring the blank concentration in all chambers for a period of about 6 hours. This provided between 60-70 readings from each RAM per day. Data from three days was used for MDL determinations for each RAM.

The value of MDL for each RAM was determined as the average blank plus three times the standard deviation of the blank, measured as described above. The average and standard deviation of the blank concentration measurements were 0.001 (± 0.007), -0.001 (± 0.005), and 0.003 (±0.001) mg gallium arsenide/m^3 for RAM#1, RAM#2 and RAM#3, respectively. From these data, the MDL was calculated to be 0.020, 0.013, and 0.006 mg/m^3 for RAM#1, RAM#2 and RAM#3.

The minimum quantifiable limit (MQL) is commonly employed in analytical chemistry. The MQL is defined as the blank concentration plus 10 times the standard deviation of the blank. Using the data obtained in the determination of MDL discussed above, the MQL was determined to be 0.071, 0.049, and 0.013 mg gallium arsenide/m^3 for RAM#1, RAM#2, and RAM#3, respectively.

The minimum limit of quantitation (MLQ) has been defined as the concentration at which the %RSD and the relative error of the measurement is ±10%. In the absence of an aerosol standard for gallium arsenide, successively lower concentrations of gallium arsenide were generated in the 0.1 and 1.0 mg/m^3 chambers. During this generation period, several readings at each lower concentration were obtained using RAM#3. Grab samples were obtained and analyzed at concentrations of approximately 0.8, 0.08, 0.04 and 0.01 mg/m^3. Corresponding RAM voltages were obtained and employed to calculate chamber concentration. The %RSD for each of these samples was found to be < 10%, indicating an MLQ less than 10 times lower than the low exposure chamber concentration (MLQ = 0.01 mg/m^3).

During prestart tests (NTP subchronic study) the precision of each RAM aerosol monitor was estimated from the average %RSD of duplicate voltage readings obtained during routine RAM calibrations. In the absence of an on-line standard for the particulate, this estimate must include both the RAM variability and the variability associated with the generation and delivery system. Nevertheless, data from the prestart phase of the gallium arsenide

subchronic study indicated the precision for repeated concentration measurements ranged from approximately 0 to 12 %RSD.

Linearity of the RAM monitors was not assumed for the gallium arsenide aerosol. Either first- or second-order polynomial was applied to the calibration data from each individual RAM. As mentioned above, the form of the calibration curve employed was chosen to minimize errors in the prediction of chamber concentration from RAM voltage data. When second-order equations were used, care was taken to assure that the instruments were operating on an upward sloping portion of the response curve.

Good collection efficiency has previously been demonstrated by our laboratory for the collection of aerosols on Gelman A/E glass fiber filters. The collection efficiency for cadmium oxide particles was investigated previously during another study (cadmium oxide repeated dose study) using three different types of filters. These filters include the Gelman A/E glass fiber filter, the Millipore Type HA filter (0.45 µm) and the Millipore Type AA filter (0.8 µm). The best collection efficiency was found with the Gelman A/E glass fiber filters, and these filters were employed for the developmental toxicity study.

Additional details of test chemical concentration monitoring may be found in the Test Chemical Concentration Monitoring Section of Appendix A.

J.A. Dill, Sr. Research Scientist

Date

MRI Chemical Analyses Report

STANDARD ANALYSIS NEW REPORT

CHEMICAL CHARACTERIZATION OF GALLIUM ARSENIDE

NIEHS CONTRACT NO. NO1-ES-45060
MRI Project No. 7098-C
MRI Task Designation: BS-1849

MIDWEST RESEARCH INSTITUTE
425 Volker Boulevard
Kansas City, MO 64110

December 11, 1986

GALLIUM ARSENIDE

Management Information

CAS NO.: 1303-00-0
MRI REQUEST NO.: 354N
MRI TASK DESIGNATION: BS-1849
SUBMITTER: National Toxicology Program
TOXICITY STUDY SUPPORTED: Carcinogenesis
MRI RECEIPT DATE: 10/13/86 (date micronized material was homogenized)
INTERIM REPORT TO NTP: Preliminary written report, 11/5/86
SUPPLIER DATA:
Company: Johnson Matthey, Inc.
Eagles Landing
P.O. Box 1087
Seabrook, NH 03874
Purchase Order Date: Batch 01 = 8/12/85, Batch 02 = 6/5/86
MRI Assigned Lot No.: M100386
MRI Batch No.: 04
Amount Available for Testing Laboratory: ~ 21.5 kg in 1 x 5-gal. metal can
Purity Grade: Not available
Manufacturer Specifications: Batch 01 = 99.99%, Batch 02 = 99.9999%
Typical Lot Analysis: Not available
Actual Lot Analysis: Not available

Chemical Information

MOLECULAR FORMULA: GaAs
MOLECULAR WEIGHT: 144.64

EXECUTIVE SUMMARY

This batch of chemical was identified as gallium arsenide. Cumulative analytical data indicated a purity of approximately 98%. These conclusions were based on the following information:

The elemental analysis results for arsenic agreed with theoretical values; however, the results for gallium were low. These results identified the material as gallium arsenide with no significant amount of the oxide present. Elemental analysis for carbon and hydrogen indicated that there are no organic impurities present. Spark source mass spectrometry indicated the following impurities present at levels greater than 100 ppm: iron, 140 ppm; silicon, 320 ppm; aluminum, 950 ppm; and magnesium, 160 ppm. All other impurities detected by spark source mass spectrometry totaled less than 180 ppm.

Weight loss on drying indicated 0.02 ± 0.01(s)% water. Chelometric titration indicated a purity of 98 ± 1(s)%.

Bulk chemical protocols for the toxicology laboratory are included in this report. These protocols are based on infrared spectroscopy and chelometric titration.

TABLE OF CONTENTS

STANDARD ANALYSIS NEW REPORT - CHEMICAL CHARACTERIZATION OF GALLIUM ARSENIDE

I. INTRODUCTION

The purpose of this work was to provide chemical support for toxicity studies. This support consisted of chemical analyses and development of protocols for the toxicology laboratory. These analyses and protocols are described in this report.

II. CHEMICAL HANDLING

This section describes procedures used to size, homogenize, and store the material after receipt at MRI.

A. PARTICLE SIZE REDUCTION

The particle size of the material was initially reduced using a ball mill, followed by micronizing. The final particle size was determined to be ~ 1 μm by transmitted light microscopy.

B. HOMOGENIZATION

After micronizing, Batch 04 of gallium arsenide was manually mixed and tumbled for approximately 5 min.

C. STORAGE

After homogenization, the dark gray powder was transferred to one 5-gal. metal can, and stored at ambient temperature.

III. CHEMICAL STUDIES

This section contains the results of identity confirmation and purity analyses for the sample of gallium arsenide.

A. CHEMICAL CHARACTERIZATION

This section contains a description of physical appearance, and the results of elemental analysis, weight loss on drying, and titration, used to evaluate the purity of the sample.

1. APPEARANCE

Dark gray to black, finely powdered solid.

2. ELEMENTAL ANALYSIS

Element	Ga	As	C	H
Theoretical % (T)	48.20	51.80	-	-
Determined % (D)	47.76 47.19 47.23	51.79 51.57	< 0.05 < 0.05	< 0.05 < 0.05
Difference from Theoretical ($\bar{D}$-T)	-0.81	-0.12	+0.05	+0.05
Relative Agreement (%) ($\bar{D}$-/T)	98.3	99.8	-	-

3. SPARK SOURCE MASS SPECTROMETRY

Elemental Concentrations in Parts Per Million by Weight[a]

Element	ppm	Element	ppm	Element	ppm	Element	ppm
Uranium	< 0.1	Terbium	< 0.1	Ruthenium	< 0.1	Vanadium	0.16
Thorium	< 0.11	Gadolinium	< 0.1	Molybdenum	6.8	Titanium	3.4
Bismuth	< 0.40	Europium	< 0.1	Niobium	0.72	Scandium	< 0.1
Lead	< 0.22	Samarium	< 0.14	Zirconium	2.3	Calcium	15
Thallium	< 0.22	Neodymium	< 0.1	Yttrium	≤ 3.7	Potassium	14
Mercury	NR[b]	Praseodymium	≤ 0.43	Strontium	1.0	Chlorine	7.4
Gold	< 0.1	Cerium	≤ 4.4	Rubidium	≤ 0.20	Sulfur	4.5
Platinum	< 0.1	Lanthanum	0.11	Bromine	< 0.28	Phosphorus	1.4
Iridium	< 0.1	Barium	≤ 1.5	Selenium	< 0.1	Silicon	320
Osmium	< 0.1	Cesium	< 0.1	Arsenic	Maj	Aluminum	950
Rhenium	IS[c]	Iodine	0.25	Germanium	< 0.1	Magnesium	160
Tungsten	< 0.25	Tellurium	< 0.1	Gallium	Maj	Sodium	34
Tantalum	S[d]	Antimony	< 0.1	Zinc	0.22	Fluorine	0.9
Hafnium	< 0.42	Tin	0.17	Copper	1.7	Oxygen	NR
Lutetium	< 0.1	Indium	IS	Nickel	26	Nitrogen	NR

Element	ppm	Element	ppm	Element	ppm	Element	ppm
Ytterbium	< 0.18	Cadmium	0.47	Cobalt	0.29	Carbon	NR
Thulium	< 0.1	Silver	< 0.1	Iron	140	Boron	1.1
Erbium	< 0.12	Palladium	< 0.1	Manganese	2.5	Beryllium	< 0.1
Holmium	< 0.1	Rhodium	< 0.1	Chromium	37	Lithium	3.2
Dysprosium	< 0.1						

a When operated in the multielement mode, spark source mass spectrometry is a semiquantitative method.
b NR = not reported.
c IS = internal standard.
d S = instrument source.

4. WATER ANALYSIS

Method: Weight loss on drying at 120°C for ~ 21 hrs
Results: 0.02 ± 0.01(s)% (n = 3)

5. CHELOMETRIC TITRATION

Procedure: Aliquots of a volumetric solution of the sample in 50% aqueous nitric acid were buffered to pH 3.5-4.0 and 0.02 M EDTA was added. The excess EDTA was titrated with 0.02 M zinc sulfate to a potentiometric endpoint. The titration was monitored with a combination silver electrode amalgamated with mercury and filled with aqueous saturated potassium nitrate.

Results: 98 ± 1(s)% (n = 4)

6. SUMMARY AND DISCUSSION

The sample was identified as gallium arsenide by elemental analysis. Elemental analysis results for arsenic agreed with theoretical values; however, the results for gallium were low. The results indicated that there was no significant amount of gallium oxide present; if the oxide were present, the Ga content would be higher than theoretical. Elemental analysis also indicated that carbon and hydrogen were each present at a concentration of less than 0.05%, indicating that there are no organic impurities present. Spark source mass spectrometry indicated the following impurities present at levels greater than 100 ppm: iron, 140 ppm; silicon, 320 ppm; aluminum, 950 ppm; and magnesium, 160 ppm. All other impurities detected by spark source mass spectrometry totaled less than 180 ppm. Weight loss on drying for approximately 21 hr at 120°C indicated 0.02 ± 0.01(s)% water.

Chelometric titration indicated a purity of 98 ± 1(s)%.

7. CONCLUSION

The sample was identified as gallium arsenide. Cumulative data indicated a purity of approximately 98% for this batch of chemical.

B. ACCELERATED STABILITY STUDY

Results of an accelerated stability study for gallium arsenide will be submitted as a supplemental report.

IV. PROTOCOLS FOR THE TOXICOLOGY LABORATORY

This section contains chemical handling and bulk chemical protocols for the toxicology laboratory.

A. CHEMICAL HANDLING PROTOCOLS

Chemical handling protocols are described in the NTP Health and Safety Package for Gallium Arsenide and should be consulted for safety and emergency procedures in handling this chemical, as well as pertinent chemical properties.

DISCLAIMER

The information contained therein is based on data from current published literature and is believed to be accurate. However, no warranty is expressed or implied regarding the accuracy of these data or the results to be obtained from the use thereof.

B. BULK CHEMICAL PROTOCOLS

This section contains protocols to be followed upon receipt of the bulk chemical, for initial confirmation of identity and purity, and for subsequent analyses of the bulk chemical during storage at the toxicology laboratory.

1. RECEIPT OF BULK CHEMICAL

a. Removal and Storage of Reference Material

When the bulk chemical is received, remove 2-g portions for each subsequent analysis. Place each sample in an appropriately labeled glass vial equipped with a Teflon®-lined screwcap, cap the vial with an inert headspace, then tightly close and seal the vial, and store at -20°C. Use this material in subsequent analyses, at intervals specified by the NTP, to replace the reference standard initially supplied by MRI.

b. Bulk Chemical Storage

Store the bulk chemical at room temperature (~25°C) under an inert atmosphere and protected from light.

2. CONFIRMATION OF IDENTITY AND PURITY OF BULK CHEMICAL

Determine whether the bulk chemical received by the toxicology laboratory is identical to that analyzed by MRI. Confirm the identity and purity of the bulk chemical as soon after receipt as practical, using elemental analysis and chelometric titration (pp. 5-11). These analyses require the concomitant analysis of a frozen reference standard supplied by MRI (shipped under separate cover).

Upon receipt, carefully inspect the standard supplied by MRI and store at -20°C prior to analysis. In case of damage to the standard, or if the shipping container does not contain dry ice, notify MRI.* Use this standard only for confirmatory identity and purity analyses upon receipt of the bulk chemical. Subsequent purity analyses (p. 11) require the use of reference material removed by the toxicology laboratory upon receipt of the bulk chemical.

a. Identity Confirmation by Elemental Analysis

The basis of this analysis is confirmation of the identity of the bulk chemical from the results of elemental analysis for gallium and arsenic.

(1) Analyze duplicate samples of the bulk chemical and reference standard for gallium and arsenic.

These analyses may be performed by the toxicology laboratory or an independent laboratory. If an independent laboratory does the analysis, it is the responsibility of the toxicology laboratory to verify the quality assurance compliance of that laboratory. However, the quality assurance compliance of the following laboratory has already been verified by MRI:

Galbraith Laboratories, Inc.**
P.O. Box 4187
2323 Sycamore Drive
Knoxville, TN 37921
Phone: (615) 546-1335

(2) Compare the results of the elemental analysis with the theoretical values as follows: gallium, 48.20%; arsenic, 51.80%.

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* Steven Graves.

** Send 0.5 g of each sample; approximately 3 weeks are required to receive results of these analyses.

b. Purity Analysis by Chelometric Titration

The basis of this analysis is the chelation of gallium with ethylenediaminetetraacetic acid (EDTA). The sample is buffered at pH 3.5-4.0 and the excess EDTA is titrated with 0.02 M zinc sulfate to a potentiometric endpoint. The titration is monitored with a combination silver electrode almagamated with mercury and filled with aqueous saturated potassium nitrate.

(1) Preparation of Equipment

Note: All water used in this analysis should be deionized unless otherwise specified.

(a) Glassware cleaning: Wash all glassware for this analysis in the following manner.

CAUTION: Do not use dichromate cleaning solutions, as indicator-blocking metal contamination may result, even after rinsing.

(i) Wet all internal glassware surfaces with 10% (v/v) nitric acid. (Caution: 10% nitric acid is corrosive; use appropriate personal protection.)

(ii) Rinse well with tested deionized water (water test below).

(b) Water test: Test deionized water source by the following method to insure that the water does not contain interfering substances.

(i) To 50 mL of water in a 150-mL Erlenmeyer flask add 0.5 mL of pH 10 ammoniacal buffer [see step (2)(d), on p. 7] and a pinch* of Eriochrome Black T indicator [see step (2)(h), p. 8].

(ii) If the color of the solution is pure blue (not red or purple). The water is free from interfering metal ions and may be used in the analysis.

(iii) If the color is not pure blue, add 0.02 M EDTA solution dropwise. If only one drop of 0.02 M EDTA is required to turn the solution pure blue, no significant interference should be experienced in the analysis.

(c) Test for contaminants: If at any time the addition of one drop of 0.02 M EDTA does not discharge the red or purple color, the water or reagents contain intolerable amounts of metal ions. To determine which solution contains the metal ions continue the test as follows:

* Sufficient indicator to produce a readily observable color change (red to blue).

(i) To the blue solution [from step (b)(iii) of Water test, p. 6], add an additional 50 mL of the water being tested. If the color becomes red, the interfering ions are entering via the water and new water should be tested.

(ii) If the solution prepared in step (b)(i) of the Water test, p. 6, is red or purple and does not turn blue with the addition of one drop of 0.02 M EDTA, continue adding 0.02 M EDTA dropwise until the red color just disappears. Add 2 mL of the pH 10 buffer. If the color turns red at this point, the buffer contains intolerable impurities and new buffer should be prepared using a different source of water or buffer reagents.

(2) Preparation of Reagents

(a) 0.02 M EDTA Solution: Accurately weigh approximately 7.6 g ACS grade disodium dihydrogen ethylenediaminetetraacetic acid into a 1-L volumetric flask and dilute to volume with water. Mix well to insure complete dissolution, then transfer the solution with minimal delay to a polyethylene bottle.

(b) 0.02 M Zinc Sulfate: Accurately weigh approximately 5.8 g of $ZnSO_4 \cdot 7\ H_2O$ into a 1-L volumetric flask and dilute to volume with water. Shake well to mix and transfer the solution to a polyethylene bottle.

(c) pH 6 Ammonium Acetate:Acetic Acid Buffer: Weigh approximately 100 g of ammonium acetate into a 200-mL volumetric flask, then dissolve and dilute to volume with water. Shake well to mix. Transfer the ammonium acetate solution to a polyethylene bottle and add 10-mL of glacial acetic acid. Swirl the solution to mix.

(d) pH 10 Ammonium Nitrate:Ammonium Hydroxide Buffer: Weigh approximately 10.5 g of ammonium nitrate into a 100-mL volumetric flask. Add 57 mL of concentrated ammonium hydroxide and dilute to volume with water. Shake well to mix. Store in a polyethylene bottle.

(e) pH 4.6 Sodium Acetate:Acetic Acid Buffer

Solution A - 0.2 M Acetic Acid: Dilute 3 mL of glacial acetic acid to 250 mL with water. Caution: Add water slowly, allowing mixture to cool before diluting to volume.

Solution B - 0.2 M Sodium Acetate ($C_2H_3O_2Na \cdot 3H_2O$): Dissolve 6.8 g of sodium acetate in water and dilute to 250 mL with water.

To prepare buffer, mix 127 mL of Solution A and 123 mL of Solution B in a 500-mL volumetric flask and dilute to volume with water.

(f) 50% Nitric Acid: Slowly add 250 mL of concentrated nitric acid to 250 mL of water. Caution: The solution will be very hot. Cool before use.

(g) 1.0 N Nitric Acid: Place ~ 75 mL of water into a 100-mL volumetric flask, then add 6.4 mL of concentrated nitric acid. Caution: The solution will be hot. Allow the solution to cool and dilute to volume with water.

(h) Eriochrome Black T Indicator: 100 mg of Eriochrome Black T and 1 g of potassium chloride mixed and ground to a fine powder.

(3) Standardization of 0.02 M EDTA with Calcium Carbonate

Note: Titrate at least triplicate samples.

(a) Titration

(i) Dry primary standard calcium carbonate for 3 hr at 300°C.

(ii) Accurately weigh approximately 35 mg of dried calcium carbonate into a 250-mL beaker. Add 6-mL of 1.0 N nitric acid to dissolve the calcium carbonate. Assure complete solution.*

(iii) Add 50 mL of water; then pipet 5 mL of pH 10 buffer into the beaker.

(iv) Monitor the titration potentiometrically over the potential range 0 to +700 mV with a combination silver electode** amalgamated with mercury and filled with a saturated aqueous potassium nitrate solution. A 35-mg sample should require about 17 mL of titrant. Note: To amalgamate the electrode, the silver tip is cleaned so that it is shiny and then dipped into a small amount of elemental mercury. The excess mercury is carefully wiped off prior to use.†

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* If calcium carbonate does not completely dissolve, add an additional 1 mL of 1.0 N nitric acid and check the solution for proper pH (pH 10) with pH paper after addition of buffer in step (3)(a)(iii), above.

** A suitable electrode is available from Brinkmann Instruments, Co., Division of Sybron Corporation, Cantiague Road, Westbury, NY 11590, Catalog No. 20 92 460-8, Model No. EA 246/6.0404.100. Electrode cables are sold separately and the catalog number is dependent on the type of instrument to be used.

† Solutions to be titrated must be free of materials which react with mercury(II) or mercury(I) ions, such as cyanide, sulfide, bromide, and large amounts of chloride.

(v) Titrate at least duplicate blanks containing 50 mL of water, the volume of 1.0 N nitric acid used to dissolve the calcium carbonate, and 5 mL of pH 10 buffer. Determine the validity of the blank by doubling the volume of water, nitric acid and pH 10 buffer. If the volume of titrant required for the larger blank is not twice that observed for the smaller blank, use zero for the blank value in the calculations.

(b) Calculations

(i) Calculate the molarity of the titrant to four significant figures, using the following formula:

$$\text{Molarity} = \frac{W \times LP}{(A - B) \times 100.09}$$

where W = weight of $CaCO_3$ (in mg),
LP = label purity of $CaCO_3$ (e.g., 99.9% = 0.999),
A = volume of titrant required for $CaCO_3$ (in mL), and
B = volume of titrant required for blank (in mL).

(ii) Calculate the average molarity and the standard deviation to four significant figures. Calculate the relative standard deviation (RSD, %) to two significant figures.

(4) Standardization of 0.02 M Zinc Sulfate

(a) Titration

(i) Volumetrically pipet a 10-mL aliquot of the standardized 0.02 M EDTA solution into a 250-mL beaker. Add 7 mL of pH 4.6 buffer and 40 mL of water and gently swirl the beaker to mix.

(ii) Titrate at least triplicate samples with the 0.02 M zinc sulfate, using the parameters and electrode system described in Section IV.B.2.b.(3)(a)(iv), p. 8. A 10-mL aliquot of the 0.02 M EDTA should require about 10 mL of titrant.

(iii) Titrate at least duplicate blanks containing 50 mL of water and 7 mL of pH 4.6 buffer. Determine the validity of the blank by doubling the volumes of water and buffer. If the volume of titrant required for the larger blank is not twice that observed for the smaller blank, use zero for the blank value in the calculations.

(b) Calculations

(i) Calculate the molarity of the titrant to four significant figures, using the following formula:

$$M_1 = (M_2 \times V_2)/(V_1 - B)$$

where M_1 = molarity of the zinc sulfate solution,
M_2 = average molarity of the EDTA solution,
B = volume of zinc sulfate required for blank (in mL),
V_1 = volume of zinc sulfate required for titration (in mL), and
V_2 = volume of the EDTA aliquot taken (in mL).

(ii) Calculate the average molarity and the standard deviation to four significant figures. Calculate the relative standard deviation (RSD, %) to two significant figures.

(5) Titration of Gallium Arsenide

Note: Prepare and titrate at least triplicate sample solutions of both the bulk chemical and the reference material.

(a) Preparation of Sample Solutions

(i) Accurately weigh approximately 150-200 mg of gallium arsenide into a 50-mL volumetric flask. Note: The sample is a finely powdered solid.

(ii) In a hood, carefully rinse any sample from the stopper into the volumetric flask, as well as rinsing down the mouth and neck of the flask, with ~ 10 mL of 50% nitric acid. Extreme caution should be taken when the nitric acid is added to the gallium arsenide as nitrous oxide gases are released. Flush the evolved gases from the flask with a gentle stream of nitrogen.

(iii) Add an additional 20 mL of 50% nitric acid and again flush the flask with nitrogen. Place the flask in a sonicator for ~ 10 min to insure dissolution of the sample. Dilute to volume with 50% nitric acid and again flush the flask with nitrogen, if needed.

(b) Titration

(i) Volumetrically pipet a 5-mL aliquot of each sample solution into individual 250-mL wide-mouth Erlenmeyer flasks, then add 20 mL of water and 7 mL of pH 6 buffer to each solution. Volumetrically pipet 20 mL of 0.02 M EDTA into each flask and swirl to mix.

(ii) Titrate samples with the standardized 0.02 M zinc sulfate. Monitor the titration potentiometrically over the potential range 0 to +700 mV with the electrode system described in Section IV.B.2.(3)(a)(iv), p. 8. A 20-mg sample (5-mL aliquot) should require approximately 11.5 mL of zinc sulfate titrant.

(iii) Titrate at least duplicate blanks containing 5 mL of 50% nitric acid, 20 mL of water, 7 mL of pH 6 buffer and 20 mL of 0.02 M EDTA (added with a volumetric pipet).

(c) Calculations

(i) Calculate the purity (%) of the bulk chemical and reference material to the tenths place using the following formula:

$$\text{Purity (\%)} = \frac{(B - A) \times M \times 144.64 \times 100}{W}$$

where B = average volume of titrant required for blanks (in mL),
A = volume of titrant required for sample (in mL),
M = average molarity of the zinc sulfate titrant, and
W = weight of sample (mg present in 5-mL aliquot).

(ii) Calculate the average purity (%) for both the bulk chemical and the reference material to the tenths place. Also, calculate the relative standard deviation (RSD, %) for each average to two significant figures.

(iii) Calculate the relative purity (%) of the bulk chemical (i.e., the purity of the bulk chemical divided by the purity of the reference material) to the tenths place.

3. SUBSEQUENT ANALYSES

Determine whether the purity of the bulk chemical remains unchanged during the toxicity study. Use reference material stored at -20°C (p. 4), in place of the standard supplied by MRI, for comparison to the stored bulk chemical. For all subsequent analyses, remove a single vial of the reference material from the freezer approximately 4 hr prior to analysis. Obtain a sample of the stored bulk chemical. Analyze the two samples concomitantly so that the two sets of test results can be directly compared.

Use the procedures and calculations contained in Section IV.B.2.b (pp. 6-11) to monitor the purity of the bulk chemical by chelometric titration at intervals specified by the NTP during the toxicity study.

V. CONTRIBUTORS

Personnel contributing to the analysis of gallium arsenide were Nancy Cameron, Calvin Patterson, Fay Gottuso, and Nadean Taylor, under the supervision of Alice Clark, and Mike Cannon.

Chemical Characterization

Linda Siemann
Chemist

Approved:

Dora W. Arneson
Dora W. Arneson, Ph.D.
Principal Investigator

D. W. Arneson
for K. M. Stelting, Ph.D.
Director
BioOrganic Chemistry Department

SUPPLEMENTARY REPORT

ACCELERATED STABILITY STUDY FOR GALLIUM ARSENIDE

NIEHS CONTRACT NO. NO1-ES-45060
MRI Project No. 7098-C
MRI Task Designation: SUB-1923

MIDWEST RESEARCH INSTITUTE
425 Volker Boulevard
Kansas City, Missouri 64110

February 5, 1987

GALLIUM ARSENIDE

Management Information

CAS NO.: 1303-00-0
MRI REQUEST NO.: 354N
MRI TASK DESIGNATION: SUB-1923
SUBMITTER: National Toxicology Program
TOXICITY STUDY SUPPORTED: Carcinogenesis
MRI RECEIPT DATE: 10/13/86 (date micronized material was homogenized)
INTERIM REPORT TO NTP: Preliminary written report, 11/5/86; standard analysis new report, 12/11/86
SUPPLIER DATA:
Company: Johnson Matthey, Inc.
Eagles Landing
Post Office Box 1087
Seabrook, NH 03874
Purchase Order Date: Batch 01 = 8/12/85, Batch 02 = 6/5/86
Company Lot No.: M100386
MRI Batch No.: 04
Amount Available for Testing Laboratory: ~ 21.5 kg in 1 x 5-gal metal can
Purity Grade: Not available
Manufacturer Specifications: Batch 01 = 99.99%, Batch 02 = 99.9999%
Typical Lot Analysis: Not available
Actual Lot Analysis: Not available

Chemical Information

MOLECULAR FORMULA: GaAs
MOLECULAR WEIGHT: 144.64

EXECUTIVE SUMMARY

The results of an accelerated stability study, monitored by chelometric titration, indicated that gallium arsenide is stable as the bulk chemical when stored, protected from light, for two weeks at temperatures up to 60°C.

SUPPLEMENTARY REPORT--ACCELERATED STABILITY STUDY FOR GALLIUM ARSENIDE

I. INTRODUCTION

The purpose of this work was to provide chemical support for toxicity studies. This support consisted of an accelerated stability study for gallium arsenide, described in this report.

II. ANALYSIS

A. PROCEDURES

Samples of gallium arsenide were stored for two weeks at temperatures of -20, 5, 25, and 60°C in amber septum vials (Teflon®-lined septa).

Samples from each temperature were analyzed by chelometric titration. Volumetric solutions were prepared using 50% aqueous nitric acid. An aliquot of each solution was buffered to pH 3.5-4.0 and 0.02 M ethylenediaminetetraacetic acid, disodium salt dihydrate (EDTA) was added. The excess EDTA was titrated with 0.02 M zinc sulfate to a potentiometric endpoint. The titration was monitored with a combination silver electrode amalgamated with mercury and filled with saturated aqueous potassium nitrate.

The gallium arsenide content (%) was calculated for samples stored at each temperature. The content of the samples stored at 5, 25, and 60°C was compared to the content of the sample stored at -20°C.

B. RESULTS

The results of the accelerated stability study of gallium arsenide are tabulated below.

Storage Temperature	Gallium Arsenide Content[a] (% of -20°C Sample)
-20°C	100 ± 2 (s) (n = 5)
5°C	99 ± 4 (s) (n = 2)
25°C	101 ± 2 (s) (n = 2)
60°C	100 ± 1 (s) (n = 2)

[a] Pooled standard deviation = 2%.

C. CONCLUSIONS

Gallium arsenide is stable, within experimental error, when stored as the bulk chemical for two weeks, protected from light, at temperatures up to 60°C. Based on the pooled standard deviation of the determined values, a miniumum of 4% loss was required to conclude, at the 95% confidence level, that gallium arsenide was unstable.

III. CONTRIBUTORS

Nancy Cameron performed this analysis of gallium arsenide.

Chemical Characterization

Linda Siemann
Chemist

Approved:

Dora W. Arneson, Ph.D.
Principal Investigator

K. M. Stelting, Ph.D.
Director
BioOrganic Chemistry Department

REVISED* ANALYSIS OF REPROCURED GALLIUM ARSENIDE AND REVISED BULK CHEMICAL PROTOCOLS

NIEHS CONTRACT NO. NO1-ES-45060
MRI Project No. 7098-C
MRI Task Designation: RE-2178

MIDWEST RESEARCH INSTITUTE
425 Volker Boulevard
Kansas City, Missouri 64110

October 26, 1988

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* Revision of RE-2178, Analysis of Reprocured Gallium Arsenide and Revised Bulk Chemical Protocols, dated October 19, 1988.

GALLIUM ARSENIDE

Management Information

CAS NO.: 1303-00-0
MRI REQUEST NO.: 354N
MRI TASK DESIGNATION: RE-2178
SUBMITTER: National Toxicology Program
TOXICITY STUDY SUPPORTED: Carcinogenesis
MRI RECEIPT DATE: 5/19/88
INTERIM REPORT TO NTP: None
SUPPLIER DATA:
- Company: Not available
- Company Lot No.: None
- MRI Assigned Lot No.: M051988
- MRI Batch No.: 06
- Amount Available for Toxicology Laboratory: - 37.6 kg; - 5 kg in seven glass bottles and 32.6 kg in one x 10-gal metal can
- Purity Grade: Not available
- Manufacturer Specifications: Not available
- Typical Lot Analysis: Not available
- Actual Lot Analysis: Not available

Chemical Information

MOLECULAR FORMULA: GaAs
MOLECULAR WEIGHT: 144.64

EXECUTIVE SUMMARY

This batch (Batch No. 06) of chemical was identified as gallium arsenide. The cumulative analytical data indicated a purity of greater than 98%. These conclusions are based on the following information:

The elemental analysis results for gallium agreed with theoretical values; however, the results for arsenic were slightly high. Elemental analysis for carbon and hydrogen indicated that no organic impurities were present. Spark source mass spectrometry indicated gallium and arsenic as the major components, with no impurities greater than 100 ppm observed. All other impurities detected by spark source mass spectrometry totaled less than 170 ppm.

Weight loss on drying indicated 0.04 ± 0.01(s)% volatiles. Chelometric titration indicated a purity of 99 ± 1(s)%.

This report also contains revised bulk chemical protocols for the toxicology laboratory. The protocols of the titration procedure were modified by increasing the pH to improve endpoint detection.

This report is revised to correct normalities in the revised protocols for the titration of gallium arsenide.

TABLE OF CONTENTS

ANALYSIS OF REPROCURED GALLIUM ARSENIDE AND REVISED BULK CHEMICAL PROTOCOLS

I. INTRODUCTION

The purpose of this work was to provide chemical support for toxicity studies. This support consisted of chemical analyses of reprocured material and revision of the bulk chemical protocols, as described in this report.

II. CHEMICAL HANDLING

This section describes procedures used to size, homogenize, and store the material after receipt at MRI.

A. PARTICLE SIZE REDUCTION

The particle size of Batch No. 04 and Batch No. 05 was reduced using a ball mill followed by micronizing. The final particle size was determined to be ~ 1 μm for Batch No. 04[1] and ~ 4 μm for Batch No. 05 by transmitted light microscopy. Batch No. 06 was prepared by combining Batch No. 04 and Batch No. 05; no particle size reduction was performed on Batch No. 06.

B. HOMOGENIZATION

Batch No. 06 of gallium arsenide was homogenized by mixing Batch No. 04 and Batch No. 05 in double plastic bags, followed by manual kneading and tumbling for approximately 15 min.

C. STORAGE

After homogenization, ~ 5 kg of gallium arsenide was repackaged into seven amber glass bottles with Teflon®-lined lids, and 32.6 kg was repackaged into one double-plastic-lined 10-gal metal can. The seven amber glass bottles were shipped immediately, and the 10-gal metal can was stored at ambient temperature (~ 25°C).

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[1] MRI Standard Analysis New Report: Chemical Characterization of Gallium Arsenide (Lot No. M100386, Batch No. 04), MRI Task Designation: BS-1849, December 11, 1986.

III. CHEMICAL CHARACTERIZATION

This section contains the results of elemental analysis, spark source mass spectrometry, weight loss on drying, and titration used to evaluate the purity of the sample of gallium arsenide.

A. APPEARANCE

Dark gray to black, finely powdered solid.

B. ELEMENTAL ANALYSIS

Element	Ga	As	C	H
Theoretical % (T)	48.20	51.80	-	-
Determined % (D)	48.09 48.09	52.78 52.75 52.37 53.18	0.04 0.05	< 0.05 < 0.05
Difference from Theoretical ($\bar{D}$-T)	-0.11	0.97	-	-
Relative agreement (%) ($\bar{D}$/T)	99.77	101.9	-	-

C. SPARK SOURCE MASS SPECTROMETRY

ELEMENTAL CONCENTRATIONS IN PARTS PER MILLION BY WEIGHT[a]

Element	ppm	Element	ppm	Element	ppm	Element	ppm
Uranium	< 0.27	Terbium	< 0.1	Ruthenium	< 0.1	Vanadium	< 0.1
Thorium	< 0.55	Gadolinium	< 0.21	Molybdenum	9.1	Titanium	< 0.1
Bismuth	< 0.40	Europium	< 0.12	Niobium	≤ 1.8(INT)	Scandium	< 0.1
Lead	< 0.27	Samarium	< 0.16	Zirconium	0.36	Calcium	3.7
Thallium	< 0.1	Neodymium	< 0.34	Yttrium	≤ 1.1(INT)	Potassium	3.2
Mercury	NR[b]	Praseodymium	≤ 4.1(INT)[e]	Strontium	≤ 0.72	Chlorine	0.63
Gold	< 0.1	Cerium	< 0.1	Rubidium	< 0.1	Sulfur	1.4
Platinum	< 0.1	Lanthanum	< 0.1	Bromine	< 0.39	Phosphorus	< 0.52
Iridium	< 0.1	Barium	< 0.15	Selenium	< 0.16	Silicon	26
Osmium	< 0.1	Cesium	< 0.1	Arsenic	Maj	Aluminum	12
Rhenium	IS[c]	Iodine	< 0.16	Germanium	< 0.15	Magnesium	< 2.7
Tungsten	< 0.35	Tellurium	< 0.1	Gallium	Maj	Sodium	< 18
Tantalum	S[d]	Antimony	< 0.12	Zinc	< 0.13	Fluorine	0.68
Hafnium	< 0.89	Tin	< 0.1	Copper	0.74	Oxygen	NR
Lutetium	< 0.1	Indium	IS	Nickel	13	Nitrogen	NR
Ytterbium	< 0.45	Cadmium	< 0.17	Cobalt	0.19	Carbon	NR
Thulium	< 0.1	Silver	< 0.1	Iron	31	Boron	0.54
Erbium	< 0.34	Palladium	< 0.1	Manganese	1.9	Beryllium	< 0.1
Holmium	< 0.1	Rhodium	< 0.1	Chromium	28	Lithium	< 0.1
Dysprosium	< 0.16						

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[a] When operated in the multielement mode, spark source mass spectrometry is a semiquantitative method.
[b] NR = not reported.
[c] IS = internal standard.
[d] S = instrument source.
[e] INT = interference by a major component spectrum.

D. WEIGHT LOSS ON DRYING

Method: Samples, dried to constant weight at 120°C (16.5 h)

Results: 0.04 ± 0.01(s)% (n = 3)

E. CHELOMETRIC TITRATION

Procedure: Aliquots of a volumetric solution of the sample in 50% aqueous nitric acid were buffered to pH 6.0, and 0.02 M EDTA was added. The excess EDTA was titrated with 0.02 M zinc sulfate to a potentiometric endpoint. The titration was monitored with a silver electrode amalgamated with mercury and filled with aqueous saturated potassium nitrate.

Result: 99 ± 1(s)% (n = 3)

F. SUMMARY AND DISCUSSION

The elemental analysis results for gallium agreed with theoretical values; however, the results for arsenic were slightly high. Elemental analysis for carbon and hydrogen indicated that no organic impurities were present. Spark source mass spectrometry indicated gallium and arsenic as the major components, with no impurities greater than 100 ppm observed. All other impurities detected by spark source mass spectrometry totaled less than 170 ppm.

Weight loss on drying indicated 0.04 ± 0.01(s)% volatiles. Chelometric titration indicated a purity of 99 ± 1(s)%.

The following table compares the results for this analysis of Batch No. 06 to the previous analysis of Batch No. 04.

	Batch No. 04[1]	Batch No. 06
Weight loss on drying	0.02 ± 0.01(s)%	0.04 ± 0.01(s)%
Titration	98 ± 1(s)%	99 ± 1(s)%

G. CONCLUSION

This batch of chemical was identified as gallium arsenide. The combined analytical data indicated a purity of greater than 98%, which is comparable to that obtained for Batch No. 04.

IV. REVISED PROTOCOLS FOR THE TOXICOLOGY LABORATORY

This section contains chemical handling and bulk chemical protocols for the toxicology laboratory.

A. CHEMICAL HANDLING PROTOCOLS

Chemical handling protocols are described in the *NTP Health and Safety Package for Gallium Arsenide* and should be consulted for safety and emergency procedures in handling this chemical, as well as pertinent chemical properties.

DISCLAIMER

> The information contained therein is based on data from current published literature and is believed to be accurate. However, no warranty is expressed or implied regarding the accuracy of these data or the results to be obtained from the use thereof.

B. BULK CHEMICAL PROTOCOLS

This section contains protocols to be followed upon receipt of the bulk chemical, for initial confirmation of identity and purity, and for subsequent analyses of the bulk chemical during storage at the toxicology laboratory.

1. RECEIPT OF BULK CHEMICAL

a. Removal and Storage of Reference Material

When the bulk chemical is received, remove 2-g portions for each subsequent analysis. Place each sample in an appropriately labeled glass vial. Cover the sample with an inert gas headspace. Seal tightly with a Teflon®-lined screw cap. Store at -20°C. Use this material in subsequent analyses, at intervals specified by the NTP, to replace the reference standard initially supplied by MRI.

b. Bulk Chemical Storage

Store the bulk chemical at ambient temperature (- 25°C) under an inert atmosphere and protected from light.

2. CONFIRMATION OF IDENTITY AND PURITY OF BULK CHEMICAL

Determine wnether the bulk chemical received by the toxicology laboratory is identical to that analyzed by MRI. Confirm the identity and purity of the bulk chemical as soon after receipt as practical, using elemental analysis and chelometric titration (pp. 6-11). These analyses require the concomitant analysis of a frozen reference standard supplied by MRI (shipped under separate cover).

Upon receipt, carefully inspect the standard supplied by MRI and store at -20°C prior to analysis. In case of damage to the standard, or if the shipping container does not contain dry ice, notify MRI.* Use this standard only for confirmatory identity and purity analyses upon receipt of the bulk chemical. Subsequent purity analyses (p. 12) require the use of reference material removed by the toxicology laboratory upon receipt of the bulk chemical.

a. Identity Confirmation by Elemental Analysis

The basis of this analysis is confirmation of the identity of the bulk chemical from the results of elemental analysis for gallium and arsenic.

(1) Analyze duplicate samples of the bulk chemical and reference standard for gallium and arsenic.

These analyses may be performed by the toxicology laboratory or an independent laboratory. If an independent laboratory does the analysis, it is the responsibility of the toxicology laboratory to verify the quality assurance compliance of that laboratory. However, the quality assurance compliance of the following laboratory has already been verified by MRI:

Galbraith Laboratories, Inc.**
P.O. Box 4187
2323 Sycamore Drive
Knoxville, TN 37921
Phone: (615) 546-1335

(2) Compare the results of the elemental analysis with the theoretical values as follows: gallium, 48.20%; arsenic, 51.80%.

b. Purity Analysis by Chelometric Titration

The basis of this analysis is the chelation of gallium with ethylenediaminetetraacetic acid (EDTA). The sample is adjusted to pH 6.0, and the excess EDTA is titrated with 0.02 M zinc sulfate to a potentiometric endpoint. The titration is monitored with a combination silver electrode amalgamated with mercury and filled with aqueous saturated potassium nitrate.

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* Steven Graves.
** Send 0.5 g of each sample; approximately 3 weeks are required to receive results of these analyses.

(1) Preparation of Equipment

Note: All water used in this analysis should be deionized unless otherwise specified.

(a) Glassware Cleaning: Wash all glassware for this analysis in the following manner.

CAUTION: Do not use dichromate cleaning solutions, as indicator-blocking metal contamination may result, even after rinsing.

(i) Wet all internal glassware surfaces with 1.1 M nitric acid. (Caution: 1.1 M nitric acid is corrosive; use appropriate personal protection.)

(ii) Rinse well with tested deionized water (water test below).

(b) Water Test: Test deionized water source by the following method to ensure that the water does not contain interfering substances.

(i) To ~ 50 mL of water in a 150-mL Erlenmeyer flask, pipet 0.5 mL of pH 10 ammoniacal buffer [see step (2)(d), on p. 8] and ~ 10 mg of Eriochrome Black T indicator [see step (2)(g), p. 8].

(ii) If the color of the solution is pure blue (not red or purple), the water is free from interfering metal ions and may be used in the analysis.

(iii) If the color is not pure blue, add 0.02 M EDTA solution dropwise. If only one drop of 0.02 M EDTA is required to turn the solution pure blue, no significant interference should be experienced in the analysis.

(iv) If the addition of one drop of 0.02 M EDTA does not change the red or purple color to pure blue, then continue to add 0.02 M EDTA until the red color just disappears.

(v) Add ~ 50 mL of the water being tested. If the color becomes red, the interfering ions are entering via the water and new water should be tested.

(vi) If, after adding 50 mL of the water being tested, the solution remains blue, then pipet 2 mL of the pH 10 buffer into the Erlenmeyer flask. If the color turns red at this point, the buffer contains intolerable impurities, and new buffer should be prepared using a different source of water or buffer reagents.

(2) Preparation of Reagents

(a) 0.02 M EDTA Solution: Accurately weigh approximately 7.6 g ACS grade disodium dihydrogen ethylenediaminetetraacetic acid dihydrate into a 1-L volumetric flask and dilute to volume with water. Mix well to ensure complete dissolution, then transfer the solution with minimal delay to a polyethylene bottle.

(b) 0.02 M Zinc Sulfate: Accurately weigh approximately 5.8 g of $ZnSO_4 \cdot 7H_2O$ into a 1-L volumetric flask and dilute to volume with water. Shake well to mix and transfer the solution to a polyethylene bottle.

(c) pH 6 Ammonium Acetate:Acetic Acid Buffer: Weigh approximately 100 g of ammonium acetate into a 200-mL volumetric flask, then dissolve and dilute to volume with water. Shake well to mix. Transfer the ammonium acetate solution to a polyethylene bottle and pipet 10 mL of glacial acetic acid into the solution. Swirl the solution to mix.

(d) pH 10 Ammonium Nitrate:Ammonium Hydroxide Buffer: Weigh approximately 10.5 g of ammonium nitrate into a 100-mL volumetric flask. Add ~ 57 mL of concentrated ammonium hydroxide and dilute to volume with water. Shake well to mix. Store in a polyethylene bottle.

(e) 8 N Nitric Acid: Slowly add ~ 250 mL of concentrated nitric acid to ~ 250 mL of water. Caution: The solution will be very hot. Cool before use.

(f) 1.0 N Nitric Acid: Place ~ 75 mL of water into a 100-mL volumetric flask, then pipet 6.4 mL of concentrated nitric acid into the flask. Caution: The solution will be hot. Allow the solution to cool and dilute to volume with water.

(g) Eriochrome Black T Indicator: Weigh ~ 100 mg of Eriochrome Black T and ~ 1 g of potassium chloride into a mortar and grind with a pestle to a fine powder.

(3) Standardization of 0.02 M EDTA with Calcium Carbonate

Note: Titrate at least triplicate samples.

(a) Titration

(i) Dry primary standard calcium carbonate for 3 h at 300°C.

(ii) Accurately weigh approximately 35 mg of dried calcium carbonate into a 250-mL beaker. Pipet 6 mL of 1.0 N nitric acid into the beaker to dissolve the calcium carbonate. If calcium carbonate does not completely dissolve, pipet an additional 1 mL of 1.0 N nitric acid.

(iii) Add ~ 50 mL of water; then pipet 5 mL of pH 10 buffer into the beaker. Determine the pH of the solution with pH paper. If the pH is not 10, adjust with concentrated nitric acid or concentrated ammonium hydroxide as required.

(iv) Monitor the titration potentiometrically over the potential range 0 to +700 mV with a combination silver electrode* amalgamated with mercury and filled with a saturated aqueous potassium nitrate solution. A 35-mg sample should require about 17 mL of titrant. Note: To amalgamate the electrode, the silver tip is cleaned so that it is shiny and then dipped into a small amount of elemental mercury. The excess mercury is carefully wiped off prior to use.**

(v) Titrate at least duplicate blanks containing ~ 50 mL of water, the volume of 1.0 N nitric acid used to dissolve the calcium carbonate, and 5 mL of pH 10 buffer. Determine the validity of the blank by doubling the volume of water, nitric acid, and pH 10 buffer. If the volume of titrant required for the larger blank is not twice that observed for the smaller blank, use zero for the blank value in the calculations.

(b) Calculations

(i) Calculate the molarity of the titrant to four significant figures, using the following formula:

$$\text{Molarity} = \frac{W \times LP}{(A - B) \times 100.09}$$

where W = weight of $CaCO_3$ (in mg),
LP = label purity of $CaCO_3$ (e.g., 99.9% = 0.999),
A = volume of titrant required for $CaCO_3$ (in mL), and
B = volume of titrant required for blank (in mL).

(ii) Calculate the average molarity and the standard deviation to four significant figures. Calculate the relative standard deviation (RSD, %) to two significant figures.

---

* A suitable electrode is available from Brinkmann Instruments, Co., Division of Sybron Corporation, Cantiague Road, Westbury, NY 11590, Catalog No. 20 92 460-8, Model No. EA 246/6.0404.100. Electrode cables are sold separately, and the catalog number is dependent on the type of instrument to be used.

** Solutions to be titrated must be free of materials which react with mercury(II) or mercury(I) ions, such as cyanide, sulfide, bromide, and large amounts of chloride.

(4) Standardization of 0.02 M Zinc Sulfate

(a) Titration

(i) Pipet a 10-mL aliquot of the standardized 0.02 M EDTA solution into a 250-mL beaker. Pipet 7 mL of pH 6.0 buffer and 40 mL of water into the beaker and gently swirl to mix.

(ii) Titrate at least triplicate samples with the 0.02 M zinc sulfate, using the parameters and electrode system described in Section IV.B.2.b.(3)(a)(iv), p. 9. A 10-mL aliquot of the 0.02 M EDTA should require about 10 mL of titrant.

(iii) Titrate at least duplicate blanks containing 50 mL of water and 7 mL of pH 6.0 buffer. Determine the validity of the blank by doubling the volumes of water and buffer. If the volume of titrant required for the larger blank is not twice that observed for the smaller blank, use zero for the blank value in the calculations.

(b) Calculations

(i) Calculate the molarity of the titrant to four significant figures, using the following formula:

$$M_1 = (M_2 \times V_2)/(V_1 - B)$$

where M_1 = molarity of the zinc sulfate solution,
M_2 = average molarity of the EDTA solution,
B = volume of zinc sulfate required for blank (in mL),
V_1 = volume of zinc sulfate required for titration (in mL), and
V_2 = volume of EDTA aliquot taken (in mL).

(ii) Calculate the average molarity and the standard deviation to four significant figures. Calculate the relative standard deviation (RSD, %) to two significant figures.

(5) Titration of Gallium Arsenide

Note: Prepare and titrate at least triplicate sample solutions of both the bulk chemical and the reference material.

(a) Preparation of Sample Solutions

(i) Accurately weigh approximately 150 to 200 mg of gallium arsenide into a 50-mL volumetric flask. Note: The sample is a finely powdered solid.

(ii) In a hood, carefully rinse any sample from the stopper into the volumetric flask, as well as rinsing down the mouth and neck of the flask, with ~ 10 mL of 8 N nitric acid. Extreme caution should be taken when the nitric acid is added to the gallium arsenide as nitrous oxide gases are released. Flush the evolved gases from the flask with a gentle stream of nitrogen.

(iii) Add ~ 20 mL more of 8 N nitric acid and again flush the flask with nitrogen. Sonicate the flask for ~ 10 min to ensure dissolution of the sample. Dilute to volume with 8 N nitric acid and again flush the flask with nitrogen, if needed.

(b) Titration

(i) Pipet a 5-mL aliquot of each sample solution into individual 250-mL beakers, then add ~ 20 mL of water and pipet 7 mL of pH 6 buffer to each solution. Volumetrically pipet 20 mL of 0.02 M EDTA into each flask and swirl to mix. With stirring, add concentrated ammonium hydroxide dropwise until the solution reaches a pH of 6.0 as measured by a pH meter. (Note: Leave pH electrode in solution to prevent sample loss.)

(ii) Titrate samples with the standardized 0.02 M zinc sulfate. Monitor the titration potentiometrically over the potential range 0 to +700 mV with the electrode system described in Section IV.B.2.b.(3)(a)(iv), p. 9. A 20-mg sample (5-mL aliquot) should require approximately 11.5 mL of zinc sulfate titrant.

(iii) Titrate at least duplicate blanks containing 5 mL of 8 N nitric acid, 20 mL of water, 7 mL of pH 6 buffer, 20 mL of 0.02 M EDTA (added with a volumetric pipet), and the volume of concentrated ammonium hydroxide required to adjust the initial pH to 6.0.

(c) Calculations

(i) Calculate the purity (%) of the bulk chemical and reference material to the tenths place using the following formula:

$$\text{Purity (\%)} = \frac{(B - A) \times M \times 144.64 \times 100}{W}$$

where B = average volume of titrant required for blanks (in mL),
A = volume of titrant required for sample (in mL),
M = average molarity of the zinc sulfate titrant, and
W = weight of sample (mg present in 5-mL aliquot).

(ii) Calculate the average purity (%) for both the bulk chemical and the reference material to the tenths place. Also, calculate the relative standard deviation (RSD, %) for each average to two significant figures.

(iii) Calculate the relative purity (%) of the bulk chemical (i.e., the purity of the bulk chemical divided by the purity of the reference material) to the tenths place.

3. SUBSEQUENT ANALYSES

Determine whether the purity of the bulk chemical remains unchanged during the toxicity study. Use reference material stored at -20°C (p. 5), in place of the standard supplied by MRI, for comparison to the stored bulk chemical. For all subsequent analyses, remove a single vial of the reference material from the freezer approximately 4 h prior to analysis. Obtain a sample of the stored bulk chemical. Analyze the two samples concomitantly so that the two sets of test results can be directly compared.

Use the procedures and calculations contained in Section IV.B.2.b (pp. 6-11) to monitor the purity of the bulk chemical by chelometric titration at intervals specified by the NTP during the toxicity study.

V. CONTRIBUTORS

Personnel contributing to the analysis of gallium arsenide were Kelly Landes, Tom Pederson, Stan Tippin, and Dan Timmons.

Chemical Characterization

Steven Graves
Senior Chemist

Approved:

Dora W. Arneson, Ph.D.
Principal Investigator

for Kathleen M. Stelting, Ph.D.
Director
BioOrganic Chemistry Department

Purity Analyses Summary

Gallium Arsenide Purity Analyses Summary

Date	Test Material	Status	Relative %Purity
06/08/88	BNW 12248-120-1*	initial	99.9
10/06,10/88	BNW 12248-123-1*	~4 months after initial	100.50
01/31/89	BNW 12248-123-1*	~ 8 months after initial	99.7
06/08/89	BNW 12248-123-1*	~ 12 months after receipt	102.6

*Lot No. M051988 Batch 06

BNW Bulk Chemical Reanalyses Reports

BULK CHEMICAL ANALYSIS

COMPOUND	Gallium Arsenide
CAS#	1303-00-0
BNW LOT#	BNW12248-120
SUPPLIER LOT#	M051988
RECEIPT DATE	5-20-88
APPEARANCE	Finely Powdered, Dk Gray Solid
STORAGE TEMPERATURE	Ambient
ANALYSIS PERIOD	Initial
ANALYSIS PROCEDURE	Method Provided by MRI, Dec 11,1986
SAMPLE ANALYSIS DATE	6-8-88
REFERENCE SAMPLE	BNW12248-118-1
NOTEBOOK REFERENCE	BNW12248-125

IDENTITY

Elemental analysis was performed by Galbraith Laboratories, Inc., Knoxville, TN

Percent Gallium Arsenide

	% Ga	% As	% GaAs
Reference Material	48.50	50.45	98.95
	48.55	50.44	98.99
Bulk Material	48.45	51.66	100.11
	48.76	51.68	100.44

Theoretical yield reported by MRI; Ga, 48.20% and As, 51.80%

ASSAY

A chelometric titration (Gallium complexed with ethylenediaminetetraacetic acid) monitored with a combination silver electrode amalgamated with mercury to a potentiometric endpoint.

Instrument: Fisher ACCUMET 825 MP

RESULTS

Relative % Purity

99.9

Bulk % purity relative to a reference material received from MRI

CONCLUSION

Elemental analysis confirms the identity of lot BNW 12248-120-1. Chelometric titrations show this lot to be 99.9% pure compared to a supplied reference material.

Signature of Technician K. A. Dey L. E. Dingel Date 8/11/88

Signature of Chemist Kathy A. Dey Date 8-11-88

BULK CHEMICAL REANALYSIS

COMPOUND	GALLIUM ARSENIDE
CAS#	1303-00-0
LOT#	BNW 12248-123-1(Vendor Lot No. M051988 MRI Batch 06)
DATE LOT RECEIVED	6-3-88
APPEARANCE	Dark gray/black crystalline powder
ANALYSIS PERIOD	4 months after initial
STORAGE TEMPERATURE	~ 25 °C
SAMPLE ANALYSIS DATE	10/6,10/88
ANALYSIS PROCEDURE	ØB-AC-3A1R-ØØ
REFERENCE SAMPLE	BNW12248-10-1 #11
NOTEBOOK REFERENCE	BNW12248-148

ASSAY: Chelometric titration with EDTA monitored to a potentiometric endpoint with a combination silver electrode that was amalgamated with mercury was used to determine the purity of gallium arsenide bulk material relative to a reference standard.

Instrument: Fisher ACCUMET 825 MP

RESULTS:

	Average % Purity	Standard Deviation	Relative % Purity
Bulk Material (BNW 12248-123-1)	102.70	0.50	100.50
Reference Material (BNW 12248-10-1 #11)	102.19	0.71	

CONCLUSION: Chelometric titration shows BNW 12248-123-1(Vendor Lot No. M051988 MRI Batch 06) to be 100.50% pure relative to a frozen reference standard.

Signature of Technician K.H. Simmons for C.W. Means Date 11/4/88

Reviewed by K.H. Simmons Date 11/4/88

Signature of Chemist J.C. Dill Date 11/4/33

BULK CHEMICAL REANALYSIS

COMPOUND: GALLIUM ARSENIDE
CAS#: 1303-00-0
LOT#: BNW12248-123-1 (Vendor Lot No.MO51988 MRI Batch 06)
DATE RECEIVED: 6-3-88
APPEARANCE: Dark gray/black crystalline powder
STORAGE TEMPERATURE: -15• C
ANALYSIS PERIOD: ~8 months after receipt
ANALYSIS DATE: 1/31/89
ANALYSIS METHOD: ØB-AC-3A1R-ØØ
REFERENCE SAMPLE: BNW12376-3-1
NOTEBOOK REFERENCE: BNW12376-25

ASSAY: Chelometric titration with EDTA monitored to a potentiometric endpoint with a combination silver electrode amalgamated with mercury was used to determine the purity of gallium arsenide bulk material relative to a reference standard.

Instrument: Fisher ACCUMET 825 MP

RESULTS:

Sample Identity	Average % Purity	Standard Deviation	Relative % Purity
Reference Material (BNW12376-3-1)	100.7	1.7	
Bulk Material (BNW12248-123-1)	100.4	0.6	99.7

CONCLUSION: Chelometric titration shows BNW12248-123-1 (Vendor Lot No. MO51988 MRI Batch 06) to be 99.7% pure relative to a frozen reference standard.

Signature of Technician Neta Sue Stamps Date 2-21-89

Review by R.E. Visintin Date 2-21-89

Signature of Chemist J.G. Dill Date 2-21-89

BULK CHEMICAL REANALYSIS

COMPOUND: GALLIUM ARSENIDE
CAS#: 1303-00-0
LOT#: BNW12248-123-1 (Vendor Lot No.MO51988 MRI Batch 06)
DATE RECEIVED: 6-3-88
APPEARANCE: Dark gray/black crystalline powder
STORAGE TEMPERATURE: ~20° C
ANALYSIS PERIOD: ~12 months after receipt
ANALYSIS DATE: 6/8/89
ANALYSIS METHOD: ØB-AC-3A1R-Ø1
REFERENCE SAMPLE: BNW12376-3-5
NOTEBOOK REFERENCE: BNW12376-148

ASSAY: Chelometric titration with EDTA monitored to a potentiometric endpoint with a combination silver electrode amalgamated with mercury was used to determine the purity of gallium arsenide bulk material relative to a reference standard.

Instrument: Fisher ACCUMET 825 MP

RESULTS:

Sample Identity	Average % Purity	Standard Deviation	Relative % Purity
Reference Material (BNW12376-3-5)	96.5	1.5	
Bulk Material (BNW12248-123-1)	99.0	1.4	102.6

CONCLUSION: Chelometric titration shows BNW12248-123-1 (Vendor Lot No. MO51988 MRI Batch 06) to be 102.6% pure relative to a frozen reference standard.

Signature of Technician Peter Sue Stamps Date 7-6-89

Review by Nancy L. Valentine Date 7-6-89

Signature of Chemist R B Stamps Date 7-6-89

Test Chemical Characterization, Storage, and Usage

I. BULK CHEMICAL

A. Test Material Receipt, Storage and Usage

1. Receipt

Gallium arsenide manufactured by Johnson Matthey, Inc. (Seabrook, N.H.) was shipped to BNW from Midwest Research Institute (MRI). A 32.6 kg shipment of gallium arsenide BNW Lot No. 12248-123 (MRI Lot No. M051988, Batch 06) was received 6/3/88. A total of 7.4 kg of gallium arsenide was transferred to the developmental toxicity study from the National Toxicology Program (NTP, Contract No. NO1-ES-65166).

Several lots of gallium arsenide were rejected prior to accepting the lot of test material used for this study. Lots were rejected on the basis of inappropriate particle size or estimated needs for the repeated dose and subchronic studies. The present lot is composed of a blend of material that was initially milled at MRI and then returned to MRI to be mixed with additional gallium arsenide.

2. Storage Conditions

Test material storage and handling procedures are addressed in the BNW Biohazards Protocol (ØB-HS-3S21). The bulk chemical was stored in Room 315 of the LSL-II building. In order to provide more convenient containers for day to day usage of the bulk chemical, the 32.6 kg lot of 6/3/88 was subdivided into 32 oz jars. As recommended by the NTP analytical contractor, storage was at room temperature (~20 °C) under an inert nitrogen atmosphere. Test material was also protected from direct exposure to light.

3. Usage

An average of 0.14 kg gallium arsenide was consumed per exposure day. A total of ~2.8 kg test material was required for the developmental toxicity study exposures.

4. Transfer Procedures

Gallium arsenide test material was transferred to the exposure generation system in the exposure system glove box which was located in a restricted access area. Aliquots of bulk material were transferred from the 32 oz jars to an exposure usage jar which was maintained with a nitrogen headspace. After transfer, the 32 oz jars were covered with a nitrogen headspace and resealed. Test material transfers were made by personnel wearing protective clothing as designated by the BNW Biohazards Protocol (ØB-HS-3S21).

5. Waste Disposal

Excess used test material was transferred to a labelled container and stored at LSL-II until it was disposed of by the BNW Waste Management and Environmental Control Group.

6. Surplus Disposal

Surplus test material was transferred back to the National Toxicology Program (NTP, Contract No. NO1-ES-65166) after completion of the developmental toxicity study.

II. Chemical Analysis

A. Analysis at Midwest Research Institute

Chemical characterization of the gallium arsenide test material was presented in the October 26, 1988 MRI report. Bulk chemical (MRI Lot No. M051988, Batch 06) was identified as gallium arsenide. Cumulative analytical data indicated a purity of greater than 98%.

Elemental analysis results showed good agreement of gallium with theoretical values. The elemental analysis results for arsenic were high; 52.8% compared to a theoretical value of 51.8% Organic impurities were found to be absent by elemental analysis. Spark source mass spectrometry indicated no impurities at levels greater than 100 ppm, and all impurities totaled less than 170 ppm.

Weight loss upon drying indicated 0.04 ± 0.01% water. Chelometric titration indicated a purity of 99 ± 1%.

B. Stability Studies at Midwest Research Institute

Accelerated stability studies performed by MRI showed the bulk chemical to be stable for at least two weeks at temperatures up to 60°C.

C. Reanalysis at Battelle Pacific Northwest Laboratories

The MRI recommended procedure based on the December 11, 1986 MRI report was implemented as BNW SOP ØB-AC-3A1M. Identity of the bulk chemical was confirmed during initial analysis by elemental analysis. Subsequent chemical analyses were performed upon receipt using chelometric titration. Chelometric titrations performed at BNW within 30 days of the projected start of the developmental toxicity study show the test material relative purity was greater than 99%. Test material purity was acceptable for the study exposures.

III. Contributors

K. H. Stoney, Technical Specialist — 5-3-90 Date

Test Chemical Concentration Monitoring

I. Test Article Concentration Monitoring

A. Monitoring System Description

Monitoring of gallium arsenide aerosol was accomplished with RAM-1 aerosol monitors. These devices use a pulsed light-emitting diode in combination with a silicon detector to sense the light scattered over a forward angle of 45° to 95° by the particles traversing the sensing volume. The instrument responds to particles in the 0.1 to 20 μm diameter size range.

A schematic of the chamber concentration monitoring system is shown in Figure A.1. The sample system used a valve to multiplex one RAM to two exposure chambers and either the control chamber or the room. Using one monitor for several chambers is superior to using a single detector for each chamber because of the ease of maintaining and assuring the calibration of a limited number of monitors. This arrangement also provided three calibration points for each RAM: two exposure concentrations and a zero point. The monitors were connected to the chambers through sample lines designed to minimize aerosol particle losses due to settling or impaction.

The output of the RAM-1 monitors was automatically read and recorded by an automated data acquisition and control system. A Hewlett-Packard HP85B computer remotely controlled the selection of the correct sample stream and the acquisition of data from the monitor. The calibration equations applied to the voltage data supplied by the RAMs were contained in the HP85B. Each chamber concentration obtained was compared with limit values for the particular location. If a chamber concentration was beyond control limits, the HP85B computer would have immediately sent the information to the executive computer for appropriate action.

Exposure concentrations for the developmental toxicity study were initially set at 10.0, 37.0, and 75.0 mg/m^3. At the beginning of the study, two additional chambers were maintained at concentrations of 0.1 and 1.0 mg/m^3 for the purpose of chamber monitor calibration. These additional chambers were initially planned for use in providing a sufficient number of points for chamber monitor calibration curves, and were not to be used for animal exposures. However, due to unexpectedly high toxicity in the female mice at the 75.0 mg/m^3 exposure concentration, the exposure concentration range for male mice was changed to 1.0, 10.0, and 37.0 mg/m^3 when male mice began exposure 12 days after the start of the study. Thus, exposure chambers were maintained at concentrations of 0.1, 1.0, 10.0, 37.0, and 75.0 mg/m^3, but the 0.1 mg/m^3 chamber was maintained only for calibration purposes.

B. Calibration of the On-Line Monitor

The calibration of the on-line monitors was performed using a method of high chemical selectivity. The RAM aerosol monitors were calibrated against chamber concentrations determined from the analysis of filter samples obtained from the exposure chambers. The samples were collected on 25 mm glass-fiber filters (Gelman Type A/E) using open-face filter holders. Gallium arsenide was dissolved from the filters with 20% nitric acid, diluted, and analyzed for gallium using graphite furnace atomic absorption spectrophotometry (GFAAS).

Anlayses of filter grab samples were performed using a Perkin-Elmer Model 5100Z Graphite Furnace Atomic Absorption Spectrophotometer with Zeeman effect background correction. Instrument and furnace conditions were similar to those recommended by the instrument manufacturer. Calibration of the GFAAS was performed by analysis of four calibration standards in the range from zero

to 250 µg/liter of gallium. Standards were prepared by serial dilution of commercial spectrometric standards. All samples and standards were analyzed in duplicate. A check standard of 100 µg/liter gallium (prepared from an NBS spectrometric standard) was analyzed immediately after calibration and after every 5 samples. If the measured concentration of the check standard was not within ±10% of the known value, the instrument was recalibrated before further analyses were performed.

The amount of gallium found by analysis of the filter samples was converted to the corresponding amount of gallium arsenide and divided by the sample volume to obtain the chamber concentration in mg/m^3. Chamber concentrations determined from analysis of filter grab samples were correlated with voltage readings from the RAMs obtained concurrently with grab samples. For each RAM, a least squares calibration equation was derived from chamber concentrations and the corresponding RAM voltage data. Either first- or second-order polynomials were used to construct the calibration equations. The form of the calibration curve employed was chosen to minimize errors in the prediction of chamber concentration from RAM voltage data. Representative calibration curves for each RAM are presented in Figures A.2 through A.4.

C. Verification of RAM Calibration

Prior to the start of the developmental toxicity, several chemical specific calibrations of the RAMs were accomplished using GFAAS. These calibrations were conducted in animal occupied chambers during the final stages of the gallium arsenide subchronic study. Additional chemical specific calibrations were determined during the developmental toxicity study.

There was no on-line standard for gallium arsenide aerosol. To ensure that chamber concentrations were within 20% of the target exposure concentrations, filter grab samples were obtained daily from exposure chambers and the amount of gallium arsenide on each filter was determined gravimetrically. If the chamber concentration determined from the gravimetric analysis was not within ±20% of the chamber target concentration, chemical specific recalibration using GFAAS was accomplished.

Prior to the start of each exposure, the presence of a proper zero reading was verified for each sampling port for each RAM. Assurance of proper operation of the RAM-1 monitors throughout each exposure day was further aided by monitoring either the room or the control chamber with each instrument. This allowed verification of a constant instrument zero reading throughout the exposure day.

D. Sensitivity and Specificity

1. Specificity

The RAM-1 monitors are not chemically specific for gallium arsenide. They respond to the presence of any particulate material within the correct size range which is sampled from the chamber. They were, however, calibrated by a method which possesses a very high chemical specificity. Experience in our laboratory indicates that the presence of animals contributes little or no measurable increase in the RAM readings at the chosen target exposure concentrations.

2. Sensitivity

During prestart testing for the gallium arsenide the minimum detectable limit (MDL) was determined for each RAM. (Note: Determinations of MDL, MQL, and MLQ were made during the prestart phase of the gallium arsenide subchronic

study, which was accomplished immediately prior to the developmental toxicity study.) At the end of a generation day, the chamber concentration was allowed to decay to zero in all chambers. During chamber decay, test material concentration in the high chamber was measured using the RAM employed to monitor the low chamber (RAM#3), until a steady state concentration near zero was achieved. At this point, all three RAMs were allowed to execute their normal duty cycle, thereby measuring the blank concentration in all chambers for a period of about 6 hours. This provided between 60-70 readings from each RAM per day. Data from three days was used for MDL determinations for each RAM. The value of MDL for each RAM was determined as the average blank plus three times the standard deviation of the blank, measured as described above. The average and standard deviation of the blank concentration measurements were 0.001 (± 0.007), -0.001 (± 0.005), and 0.003 (±0.001) mg gallium arsenide/m^3 for RAM#1, RAM#2 and RAM#3, respectively. From these data, the MDL was calculated to be 0.020, 0.013, and 0.006 mg/m^3 for RAM#1, RAM#2 and RAM#3.

The minimum quantifiable limit (MQL) is commonly employed in analytical chemistry. The MQL is defined as the blank concentration plus 10 times the standard deviation of the blank. Using the data obtained in the determination of MDL discussed above, the MQL was determined to be 0.071, 0.049, and 0.013 mg gallium arsenide/m^3 for RAM#1, RAM#2, and RAM#3, respectively.

The minimum limit of quantitation (MLQ) has been defined as the concentration at which the %RSD and the relative error of the measurement is ±10%. In the absence of an aerosol standard for gallium arsenide, successively lower concentrations of gallium arsenide were generated in the 0.1 and 1.0 mg/m^3 chambers. During this generation period, several readings at each lower concentration were obtained using RAM#3. Grab samples were obtained and analyzed at concentrations of approximately 0.8, 0.08, 0.04 and 0.01 mg/m^3 . Corresponding RAM voltages were obtained and employed to calculate chamber concentration. The %RSD for each of these samples was found to be <10%, indicating an MLQ less than 10 times lower than the low exposure chamber concentration (MLQ = 0.01 mg/m^3).

E. Precision, Linearity and Absolute Recovery

During prestart tests (NTP subchronic study) the precision of each RAM aerosol monitor was estimated from the average %RSD of duplicate voltage readings obtained during routine RAM calibrations. In the absence of an on-line standard for the particulate, this estimate must include both the RAM variability and the variability associated with the generation and delivery system. Nevertheless, data from the prestart phase of the gallium arsenide subchronic study indicated the precision for repeated concentration measurements ranged from approximately 0 to 12 %RSD.

Linearity of the RAMs was not assumed for the gallium arsenide aerosol. Either first- or second-order polynomial was applied to the calibration data from each individual RAM. As mentioned above, the form of the calibration curve employed was chosen to minimize errors in the prediction of chamber concentration from RAM voltage data. When second-order equations were used, care was taken to assure that the instruments were operating on an upward sloping portion of the response curve.

The calibration scheme employed for this study accounted for any possible effects of the on-line sample system in that the filter samples obtained from the chamber were correlated with monitor readings observed while the grab samples were being obtained. Absolute recovery using the filter sample collection and analysis methods is discussed below.

Good collection efficiency has previously been demonstrated by our laboratory for the collection of aerosols on Gelman A/E glass fiber filters. The collection efficiency for cadmium oxide particles was investigated previously during another study (cadmium oxide repeated dose study) using three different types of filters. These filters include the Gelman A/E glass fiber filter, the Millipore Type HA filter (0.45 µm) and the Millipore Type AA filter (0.8 µm). The best collection efficiency was found with the Gelman A/E glass fiber filters.

II. Monitoring for Gallium Arsenide in Building Exhaust

Measurements of gallium arsenide in the LSL-II building exhaust were accomplished during the developmental toxicity study to demonstrate environmental compliance and to demonstrate the effectiveness of the treatment system for the exposure system. Gallium arsenide in the effluent from the exposure system is removed by passing the effluent through two series of high efficiency particulate (HEPA) filters prior to exhausting the effluent. Samples were collected from the treated exhaust and analyzed for gallium using GFAAS.

Samples were collected on Teflon-coated, glass-fiber filters using an isokinetic sampling device. Gallium arsenide was dissolved from the filters with aqueous nitric acid and the solution analyzed for gallium using GFAAS. In addition three handling blanks were prepared. These were prepared by placing the filters in the same holder as used for the samples. The filters were removed without drawing atmosphere and prepared for GFAAS analysis in the same fashion as the sample filters.

After blank correction, the amount of gallium determined in the building exhaust samples was less than the minimum detection limit for GFAAS (2 µg/l). Consequently, the upper limit for the gallium arsenide concentration in the building exhaust was found to be less than 1.6×10^{-3} mg/m^3.

III. Contributors

K. H. Stoney, Technical Specialist — 5.3.90 Date

R. E. Hauber, Chemistry Technician — 5.3.90 Date

J. A. Dill, Sr. Research Scientist — 5/3/90 Date

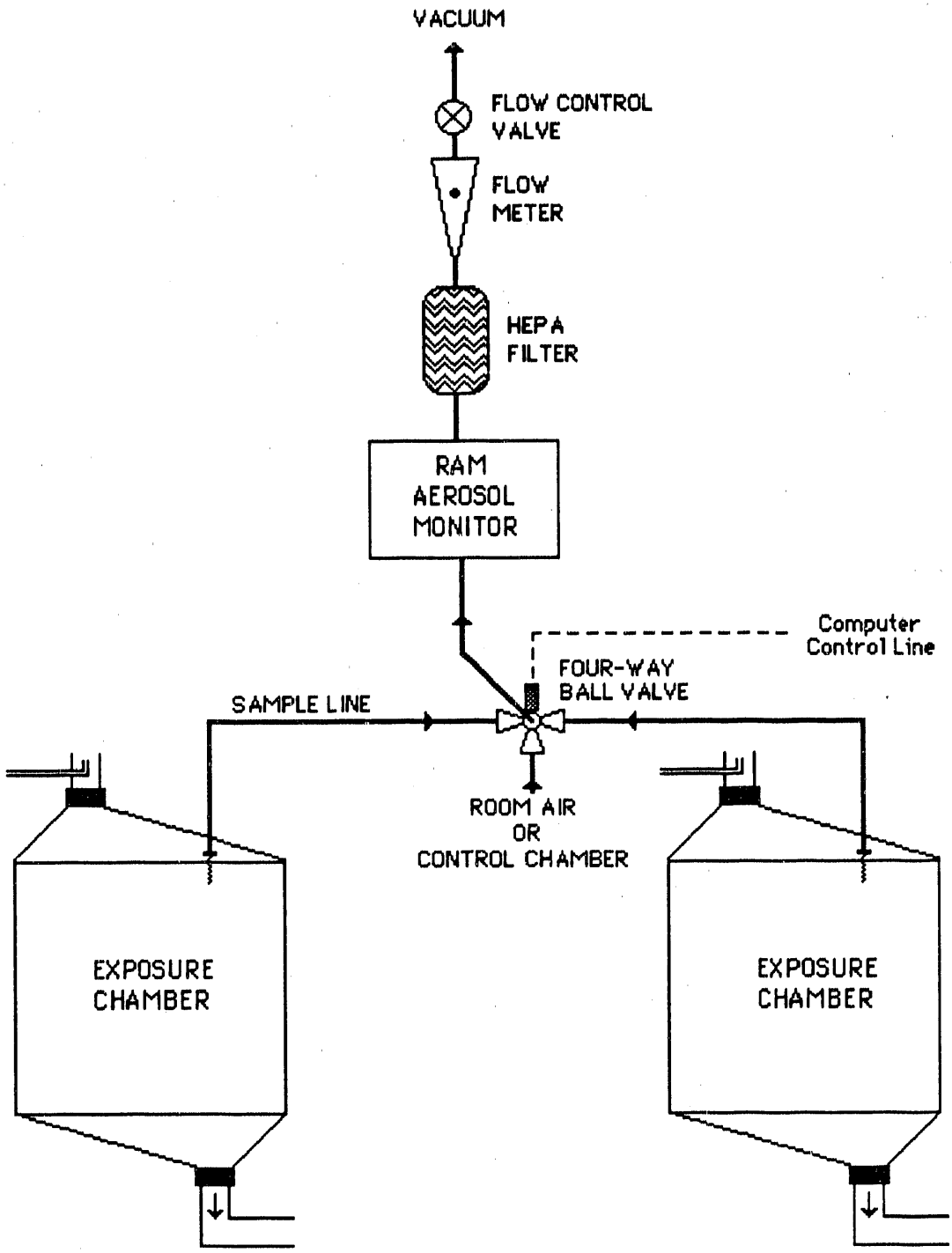

FIGURE A.1. Schematic Diagram of the Exposure Chamber On-Line Monitoring System.

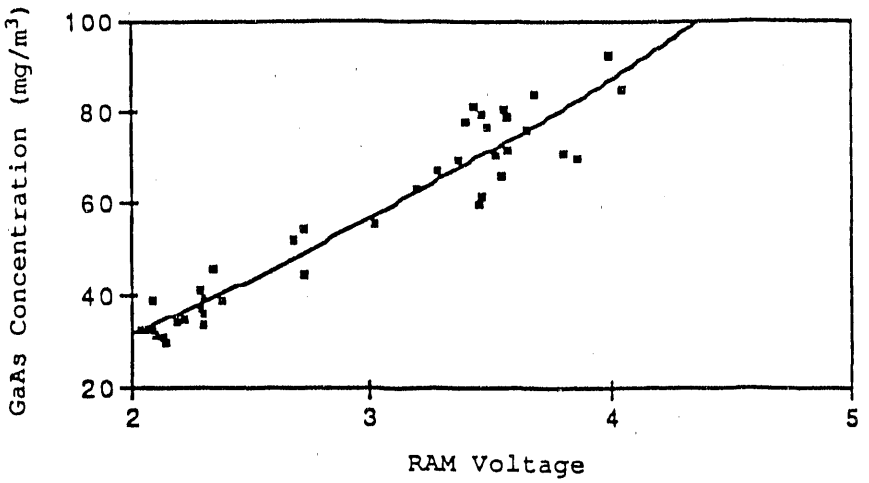

FIGURE A.2. Example Calibration Curve for RAM #1. This RAM is used to monitor the 37 mg/m^3 chamber and 75 mg/m^3 chambers. (Concentration = 9.866 * Volts + 2.966 * (Volts)^2 and Correlation Coefficient = 0.96)

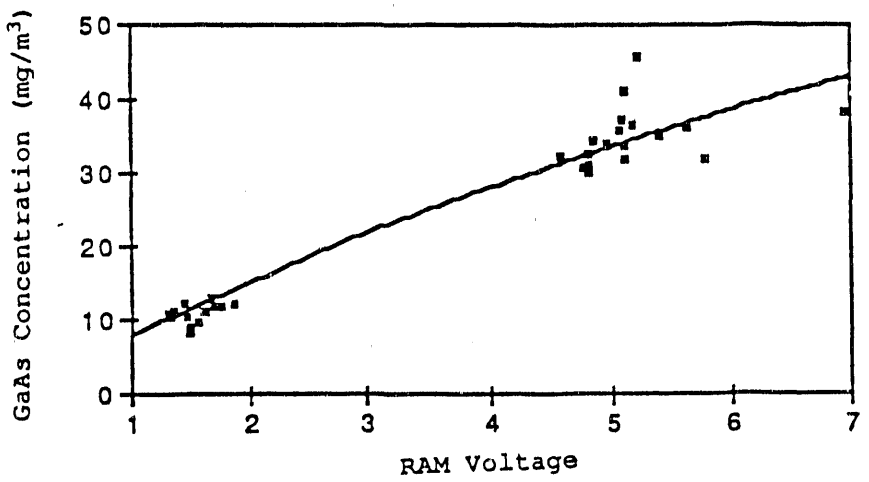

FIGURE A.3. Example Calibration Curve for RAM #2. This RAM is used to monitor the 10 mg/m^3 chamber and 37 mg/m^3 (for calibration purposes only) chambers. (Concentration = 8.12* Volts-0.281 * (Volts)^2 and Correlation Coefficient = 0.97)

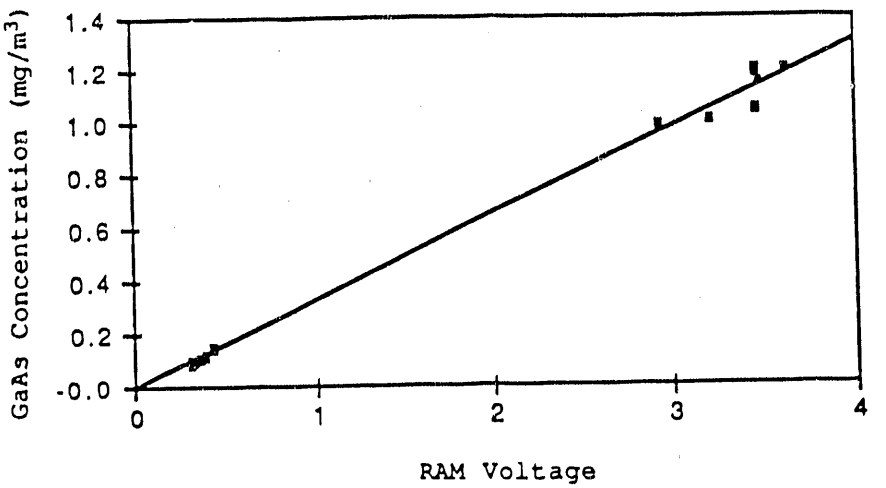

FIGURE A.4. Example Calibration Curve for RAM #3. This RAM is used to monitor the 0.1 mg/m^3 chamber (for calibration purposes only) and 1 mg/m^3 chambers. (Concentration = 0.3267 * Volts and Correlation Coefficient = 0.998)

Test Chemical Stability in the Exposure System

I. Introduction

Test article stability in the exposure system was investigated prior to the start of the developmental toxicity study, during other toxicity studies that were conducted for the NTP (gallium arsenide repeated dose and subchronic studies). Additional investigations of test article stability were carried out during the first week of the developmental toxicity study. All test article stability studies accomplished to date are summarized below, and details are provided for the studies accomplished as part of the developmental toxicity study.

Gallium arsenide undergoes oxidation in the presence of atmospheric oxygen. However, once a protective oxide surface layer is formed, further oxidation of the material is retarded. The extent of this oxidation was examined in detail by x-ray photoelectron spectroscopy (XPS) during the gallium arsenide repeated dose study. These studies indicated that the surface of the test material contains gallium oxide, arsenic trioxide, and gallium arsenide. The molar ratio of gallium oxide to gallium arsenide in the surface oxide layer ranged from approximately 0.24 to 0.30, whereas the molar ratio of arsenic trioxide to gallium arsenide ranged approximately from 0.18 to 0.25. The XPS analysis indicated that the oxidation observed was confined to a surface layer depth of approximately 50 to 100 Å.

Although surface oxidation does occur in this test material, the relative amount of oxidized material is expected to be quite small, and confined to the outermost surface layers of the material. Any significant oxidation of the test material (more than 1-2%) would likely be detected using conventional x-ray powder diffraction analysis. However, in order to gain a more complete understanding of the nature and extent of this oxidation, additional analyses were performed prior to the subchronic study, with scanning transmission electron microscopy (STEM) in the transmission mode using the techniques of convergent beam electron diffraction (CBED) and selected area diffraction (SAD). These analyses showed a shell of polycrystalline material approximately 50Å in thickness around some of the gallium arsenide particles. This result is supported by previous analyses obtained with x-ray photoelectron spectroscopy, which indicated a surface layer containing significant quantities of gallium and arsenic oxides with a layer thickness of 50-100 Å. This result shows that the extent of oxidation is very small, and is further supported by oxygen measurements using XRF spectroscopy (thin window detector) as described below. Transmission Electron Microscope (TEM) measurements were not repeated during the developmental toxicity study.

Prior to the subchronic study, the relative concentrations of oxygen, gallium and arsenic in the test material surface layer using energy dispersive x-ray fluorescence spectroscopy (XRF) with a thin-window detector. Although small amounts of oxygen were detected, this analysis indicated that the amount of oxygen in the test chemical was <0.5% relative to gallium arsenide. When repeated during the subchronic study, this analysis indicated the relative amounts of gallium (47.9 ± 1.2%) and arsenic (52.1 ± 1.2%) were quite near the theoretical gallium arsenide composition (48.2% Ga, 51.8% As). Oxygen was below the detection limit (<0.5%) for this method of analysis. These measurements were not repeated for the developmental toxicity study.

Test article stability was investigated using x-ray diffraction analysis (XRD) to determine the crystalline phases present in samples of gallium arsenide from the exposure system. XRD has a detection limit for various crystalline

phases of 1-2% by volume, although this figure can vary somewhat depending on the amount of material available, sample preparation and analysis method, and interferences due to phase mixtures. XRD is useful in determining whether gross changes have occurred in the test material resulting from reaction with atmospheric gases such as carbon dioxide, oxygen, and water. XRD is also useful in detecting the introduction of metallic crystalline impurities that may be result from mechanical abrasion in the generation system.

Analysis of samples from occupied and unoccupied exposure chambers and from exposure generation system were completed as part of the NTP repeated dose and subchronic studies. Analysis of x-ray diffraction patterns of these samples indicated only the presence of gallium arsenide. No crystalline phases other than gallium arsenide were observed in any of the samples analyzed using this technique. Although other phases were likely present in the surface layer of the test material (gallium and arsenic oxides), the relative amounts of these phases in the material were smaller than the detection limits for conventional x-ray diffraction analysis (1-2% by volume). XRD analyses were repeated during the developmental toxicity study as described below in Section II.

During previous studies, possible contamination of the test article by materials in the exposure generation system was investigated using x-ray fluorescence (XRF) spectroscopy and inductively coupled plasma-mass spectrometry (ICP-MS). This portion of the stability studies was designed to determine whether metallic impurities were introduced into the generated test atmosphere by the generation system. Gallium arsenide is expected to be quite stable within the generation system. However, small amounts of metallic impurities could be introduced into the system as a result of test chemical generation. The generator contains a number of parts constructed of stainless steel and brass, and the liner on the Trost mill is constructed of tungsten carbide. These metallic parts are all subject to abrasion by the mechanical action of the dust as it moves through the generator.

Although significant contamination of the generated test article from these sources is not likely, analyses were conducted to demonstrate that such contamination does not occur. These analyses indicated that the relative amounts of Ga and As in the collected samples were very close to the theoretical amounts expected in gallium arsenide. Although, minor amounts of metallic impurities were detected in samples from the exposure chambers, these impurities were all present at very low concentrations (<1% by weight). Analyses for metallic impurities in the exposure generation system were repeated using XRF analysis during the first week of the developmental toxicity study as described below in Section II.

II. Experimental and Results

A. Test Chemical Identification by X-Ray Diffraction Analysis

To demonstrate that the test article remains unchanged in the exposure system, samples were collected and analyzed by x-ray diffraction analysis (XRD). Samples were collected from the occupied 10 and 75 mg/m^3 chambers, and from the aerosol distribution line during a 6 hour test generation period. Filter samples were obtained using a flow sampler to collect gallium arsenide test material on Millipore Type AA filter discs (25 mm). Approximately 3.87 mg, 8.97 mg, and 14.5 mg of gallium arsenide were collected from the 10 mg/m^3 chamber, the 75 mg/m^3 chamber, and the distribution line, respectively (assuming the concentration of gallium arsenide in the distribution line is 225 mg/m^3). Samples from the generator reservoir (brush feed hopper) were

collected at the beginning and end of the 6-hour generation period. These samples and a sample of the bulk test material were submitted for XRD analysis (BNW 52934 page 24).

Filter samples were cut in half and mounted on a glass slide with high vacuum grease. Generator reservoir and bulk chemical samples (gallium arsenide powder) were placed on a glass slide with vacuum grease. Glass slide substrates were selected to minimize background interferences.

Analyses were conducted on a Phillips 3600 diffraction unit using copper Kα radiation. The XRD unit was operated at 40 kV and 25 mA. Data was collected in a step scanning mode using 0.02 degree steps and a count time of 1 second, through a range of 3 to 80 degrees 2Θ. Phase identification was accomplished by reference to files from International Centre for Diffraction Data (ICDD/JCPDS) files. An example of the gallium arsenide x-ray diffraction pattern from the distribution line is shown in Figure A.5.

The x-ray diffraction patterns of the chamber samples, generator reservoir samples, and bulk chemical were entirely consistent with the pattern expected from gallium arsenide (gallium arsenide, cubic). No indication of crystalline phases other than gallium arsenide was observed in any of the samples. No evidence of any oxidized phases such as Ga_2O_3 and As_2O_3 was observed. Thus, although these oxidized phases have previously been shown to be present using XPS and TEM analysis, their concentration is less than the XRD analysis detection limit of 1 to 2% by volume.

B. Analysis for Metallic Impurities using X-Ray Fluorescence Spectroscopy

Samples were collected and analyzed by energy dispersive x-ray fluorescence (XRF) spectroscopy. Samples were collected from the unoccupied 10 and 75 mg/m^3 chambers, and from the aerosol distribution line during a 6 hour test generation period. Samples were obtained using flow sampler to collect gallium arsenide test material on Millipore Type FH, polyethylene-backed, Teflon® filter discs (25 mm). Approximately 1.29 mg, 1.24 mg, and 0.83 mg of gallium arsenide were collected from the 10 mg/m^3 chamber, the 75 mg/m^3 chamber, and the distribution line, respectively (assuming the concentration of gallium arsenide in the distribution line is 225 mg/m^3). Samples of from the generator reservoir (brush feed hopper) were collected at the beginning and end of the day. A sample of the bulk test material was also submitted for XRF analysis (BNW 52934 page 23).

Filter samples and samples of gallium arsenide powder were placed between two thin sheets of Parafilm® and analyzed using energy dispersive x-ray fluorescence spectroscopy. Sample excitation was accomplished using bremsstrahlung radiation from a tungsten x-ray tube to excite secondary radiation sources of titanium, zirconium, silver, and americium. Secondary source irradiations were used to excite the samples. Analyses were conducted using a KEVEX 0810 XRF unit, and a Canberra Series 80 multichannel analyzer. Analyses for Ga, As, Fe, Cu, Zn, Cr, Ni, Mn, W and Mo are reported in Table A.1. The values reported in Table A.1 are corrected for the small amounts of the elements of interest in the filter material.

In addition to those values reported in Table A.1, minor amounts of potassium, calcium, strontium, and silicon were detected. These elements were observed only in the samples collected on filters, and are possibly a result of

variability in the amount of these elements in the filters used for sample collection. Elevated values for potassium, calcium and silicon may also result from contamination of the chamber samples by ambient dust or animal food particles.

III. Discussion

X-Ray diffraction analysis on samples from the test chemical generation system indicated that the material was principally gallium arsenide. These results were in good agreement with analyses obtained during previous studies. Previous analyses have shown that there is a surface oxide coating (50-100 Å thick) which probably consists of gallium and arsenic oxides. Analyses by x-ray fluorescence spectroscopy indicated that the overall extent of oxidation is quite small (<0.5%).

Analyses for metallic impurities introduced by the test chemical generation system indicated the presence of minor amounts of iron, chromium, copper, and nickel . These impurities were observed in comparable amounts in the test material and were present at concentrations that were <1% by weight. Test chemical stability and purity were considered acceptable for the study.

IV. Contributors

J. A. Dill

J. A. Dill, Sr. Research Scientist

5/5/93

Date

TABLE A.1. Results of Analyses for Impurity Metals by X-Ray Fluorescence Spectroscopy

	Relative Concentration (Weight %)		
Element	10 mg/m^3 Chamber	75 mg/m^3 Chamber	Distribution Line
Ga	49.0	49.5	49.9
As	50.6	50.2	49.8
Fe	0.178	0.119	0.146
Cu	0.028	0.030	0.029
Zn	<0.021	<0.019	<0.018
Cr	<0.077	0.032	0.037
Ni	0.041	0.023	0.031
Mn	<0.058	<0.025	<0.023
Mo	<0.014	<0.005	<0.005
W	<0.085	<0.037	<0.034
Element	Generator (Beginning)	Generator (End)	Bulk Material
Ga	50.4	50.6	53.3
As	49.1	49.1	46.4
Fe	0.348	0.151	0.154
Cu	0.022	0.025	0.031
Zn	<0.015	<0.017	<0.014
Cr	<0.025	0.036	0.034
Ni	0.011	0.015	0.019
Mn	<0.019	<0.021	<0.017
Mo	<0.004	<0.005	<0.003
W	<0.029	<0.034	<0.026

Theoretical values 48.2% Ga, 51.8% As

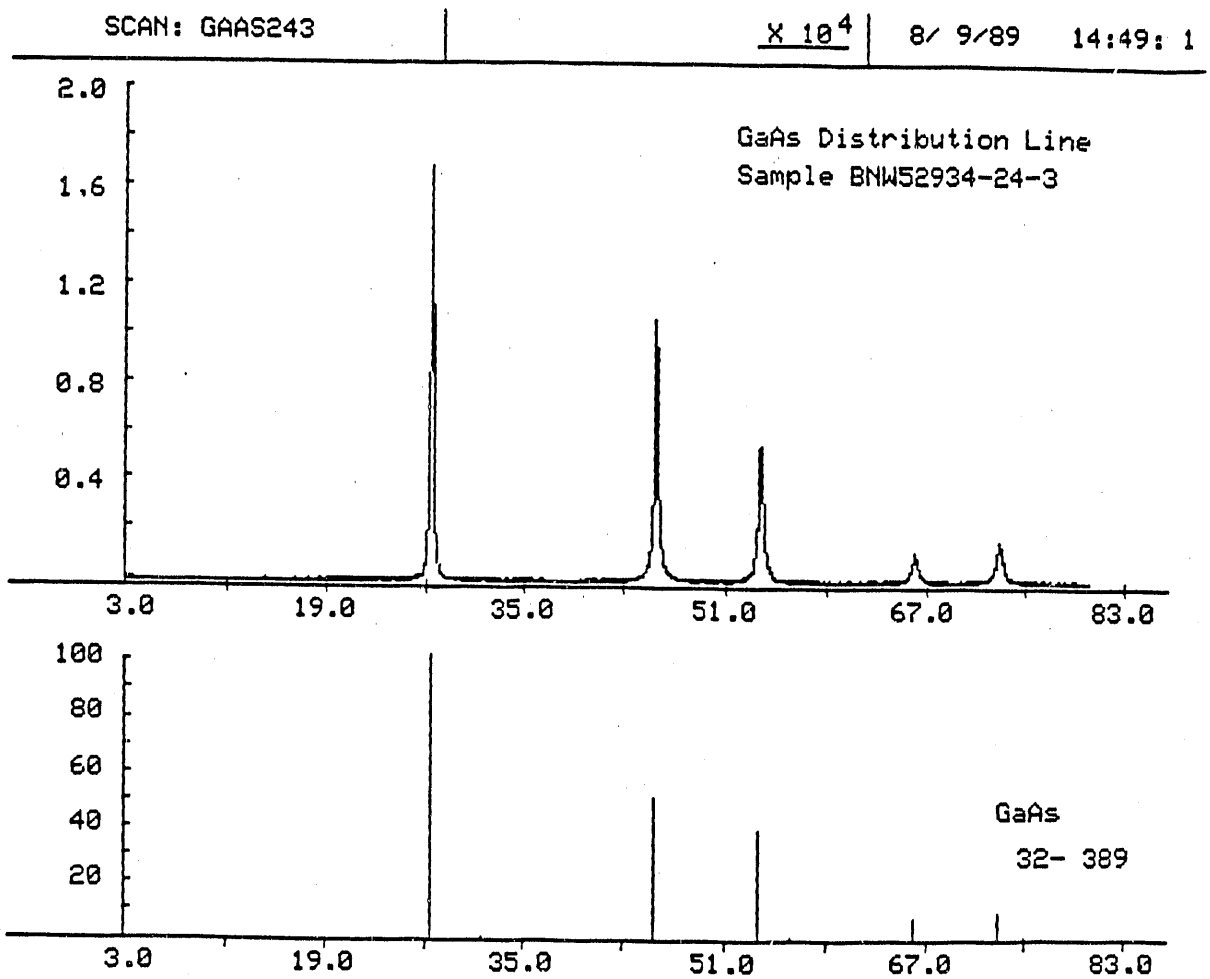

FIGURE A.5. Example of X-ray Diffraction Pattern Obtained on Gallium Arsenide Sample from the Distribution Line. Plot is relative intensity (y-axis) vs degrees 2θ. Lower portion is ICDD/JCPDS reference pattern for gallium arsenide.

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Ms. K. H. Stoney
Battelle Pacific Northwest Laboratories
Biology and Chemistry Dept, LSL-II, K4-10
P. O. Box 999
Richland, Washington 99352

July 13, 1988

Received: June 28th

Dear Ms. Stoney:

Analysis of your compounds gave the following results:

Your #,	Our #,	% Ga,	% As,
BNW 12248-130-1	A-8842	48.50	50.45
		48.55	50.44
BNW 12248-130-2	A-8843	48.45	51.66
		48.76	51.68

Rec'd 7/19/88 KHS
original to Chemistry File

Sincerely yours,

GALBRAITH LABORATORIES, INC.

Gail R. Hutchens
Exec. Vice-President

GRH:pd

APPENDIX B

CHEMISTRY DISTRIBUTION NARRATIVE AND DATA

Experimental Methods and Results

Experimental Methods and Results

I. Chemistry Distribution: Experimental Methods and Results

A. Sample Preparation and Analysis

Weighed tissue samples ranging from approximately 0.1 to 2.0 grams (wet tissue weight) were placed in a closed, acid digestion vessel (Parr Bomb, Model 4749) and 1-3 ml of concentrated, ultrapure, nitric acid was added. Each vessel was sealed and the contents digested in an oven at 110-130°C for ~3 hours. After cooling, the bomb contents were quantitatively transferred to a volumetric flask and diluted to the appropriate volume with a final acid strength of ~2% HNO_3. If necessary, subsequent dilutions were performed to produce a final gallium or arsenic concentration in the range from approximately 10 to 160 µg/l.

Samples were analyzed for gallium and arsenic using a Perkin-Elmer Model 5100 Atomic Absorption Spectrophotometer, with an HGA 600 Graphite Furnace equipped with Zeeman effect background correction and Model AS-60 Autosampler. For both gallium and arsenic analysis, the graphite furnace was equipped with graphite tubes fitted with a sample (L'Vov) platform constructed of pyrolytic carbon. The furnace heating programs for gallium and arsenic determinations are shown in Table B.1 and Table B.2, respectively. Spectrophotometer parameters for the analysis of gallium and arsenic are shown in Table B.3 and Table B.4, respectively.

Sample matrix interferences were attenuated through sample dilution and the addition of matrix modifier to the graphite furnace immediately prior to analysis of each sample. Arsenic was determined using a nickel nitrate matrix modifier containing approximately 16 g/l of nickel nitrate hexahydrate. Ten µl of nickel nitrate matrix modifier was added to the graphite furnace concurrently with 25 µl aliquots of standards and samples. Gallium was determined using a matrix modifier consisting of a digested blank tissue sample of approximately the same size as study samples. Ten µl of matrix modifier was added to the graphite furnace concurrently with 15 µl aliquots of standards and samples. Because of relatively high dilution factors used in their preparation, no significant gallium blank was observed in these matrix modifier solutions.

Standards were analyzed first to generate a calibration curve, followed by analysis of samples. Standards were prepared from commercial spectrometric standards at concentrations of 10, 40, 100, and 160 µg/l each of Ga and As in ~2% nitric acid solution. A check standard containing 100 µg/l each of Ga and As was analyzed after calibration and after approximately every five samples. The analyzed concentration of the check standard was required to be within ±10% of the known value or the instrument was recalibrated. All samples and standards were analyzed in duplicate.

Zinc determinations were performed by flame atomic absorption spectrophotometry using a Perkin-Elmer Model 5100-PC Atomic Absorption Spectrophotometer Model AS-51 Autosampler. Spectrophotometer conditions for zinc determinations are shown in Table B.5. For analysis of zinc in rat and mouse testes, samples were digested as described above and diluted to give final solutions that contained ~1% KCl and ~2% HNO_3 with a zinc concentration in the range from approximately 0.1 to 0.9 mg/l. The spectrophotometer was calibrated using standards of 0.15, 0.30, 0.45, 0.60, 0.75, and 0.90 mg/l

TABLE B.1. Furnace Heating Program for Graphite Furnace Atomic Absorption Spectrophotometer for Analysis of Gallium in Tissue Samples.

Step	Temperature (°C)	Ramp Time (s)	Hold Time (s)	Internal Flow[a] (ml/min)
1	150	20	40	300
2	700	10	20	100
4	2200	0	5	0[b]
5	2600	1	5	300
6	20	1	5	300

[a]Flow rate of internal argon purge (ml/min).
[b]Atomic absorption measured during this step.

TABLE B.2. Furnace Heating Program for Graphite Furnace Atomic Absorption Spectrophotometer for Analysis of Arsenic in Tissue Samples.

Step	Temperature (°C)	Ramp Time (s)	Hold Time (s)	Internal Flow[a] (ml/min)
1	150	20	50	300
2	1500	30	15	100
4	2200	0	6	0[b]
5	2600	1	5	300
6	20	1	5	300

[a]Flow rate of internal argon purge (ml/min).
[b]Atomic absorption measured during this step.

TABLE B.3. Instrument Conditions for Graphite Furnace Atomic Absorption Spectrophotometer for Analysis of Gallium in Tissue Samples.

Conditions	Instrument Settings
Lamp	Hollow Cathode
Lamp Current (mA, modulated)	6
Lamp Energy	45-46
Wavelength (nm)	287.4
Slit (nm)	0.7
Read Delay (s)	0
Background Correction (Type)	Zeeman Effect
Background Offset Correction Time (s)	2
Integration Time (s)	5
Measurement Type	Peak Area
Number of Replicates	2
Standard/Sample Volume (µl)	15
Modifier Volume (µl)	10
Matrix Modifier	Digested Blank Tissue Sample
Calibration Standards	0, 10, 40, 100, 160 µg Ga/liter
Calibration Type	Non-linear

TABLE B.4. Instrument Conditions for Graphite Furnace Atomic Absorption Spectrophotometer for Analysis of Arsenic in Tissue Samples.

Conditions	Instrument Settings
Lamp	Electrode-less Discharge
Lamp Power (Watts, modulated)	7-8
Lamp Energy	60-65
Wavelength (nm)	193.7
Slit (nm)	0.7
Read Delay (s)	0
Background Correction (Type)	Zeeman Effect
Background Offset Correction Time (s)	1
Integration Time (s)	6
Measurement Type	Peak Area
Number of Replicates	2
Standard/Sample Volume (µl)	25
Modifier Volume (µl)	10
Matrix Modifier	16 g/liter Nickel Nitrate•$6H_2O$
Calibration Standards	0, 10, 40, 100, 160 µg As/liter
Calibration Type	Non-linear

TABLE B.5. Instrument Conditions for Flame Atomic Absorption Spectrophotometer for Analysis of Zinc in Rat and Mouse Testes.

Conditions	Instrument Settings
Lamp	Hollow Cathode
Lamp Power (mA, modulated)	15
Lamp Energy	63
Wavelength (nm)	213.9
Slit (nm)	0.7
Read Delay (s)	10
Background Correction (Type)	Deuterium Arc Continuum
Integration Time (s)	5
Measurement Type	Integrated Absorbance
Matrix Modifier	1% KCl
Fuel/Oxidizer	Acetylene/Air (~1:9 ratio)
Calibration Standards	0, 0.15, 0.3, 0.45, 0.60, 0.75, and 0.9 mg Zn/liter
Number of Replicates	3
Calibration Type	Linear

zinc. In order to detect calibration drift, the 0.6 mg/l standard was analyzed after every fifth sample, and the instrument was recalibrated if analysis of this check standard was in error by more than ±10%.

B. Method Performance Evaluations

1. Recovery Studies

The purpose of the method performance evaluation (MPE) is to establish satisfactory performance of the analytical methods employed for biological sample analysis. The key elements of this evaluation are to provide indications of method precision, accuracy, and interferences over the analyte concentration range expected in actual samples. Because these factors depend significantly on matrix effects and potential interferences present in the actual samples, method performance must be demonstrated by analysis of samples which are representative of the actual samples in terms of total chemical composition. Consequently, the MPE makes extensive use of analyte measurements in spiked tissue samples. These measurements allow estimation of analyte recovery, method precision, and accuracy in samples that are very similar to biological samples obtained from test animals.

The concentration range for recovery studies was established by preliminary analysis of actual tissue samples from the study. These limited analyses were accomplished using a method which was already sufficiently developed to provide satisfactory performance over the concentration range observed in these samples. From the analysis of these samples, the concentration range for the method performance evaluation was established.

Blank tissues were spiked with various amounts of Ga, As, or Zn and digested in Parr bombs with concentrated nitric acid. Spiked tissue samples were then diluted to volume and analyzed as described above. Spikes were added via addition of known volume aliquots of aqueous standards. For most tissues, the mass of the spiked tissue samples varied from approximately 1-2 grams. However, with certain tissues (e.g. uterine contents), sample mass was approximately 0.1 gram or less. Blank tissue sample mass employed for recovery studies was chosen to be approximately the same mass as study samples.

Blank tissue samples were prepared and analyzed in the same manner, except no spikes were added. Most of the blank samples did not show significant quantities of gallium or arsenic. However, blank blood samples from rats contained endogenous arsenic at concentrations of approximately 7-15 µg/g and testes from both rats and mice contained zinc at concentrations of approximately 11-15 µg/g. In order to reduce inter-animal variations in the endogenous amount of arsenic, pooled rat blood samples were used in the recovery studies. Similarly, blank testes were pooled and homogenized for use in the recovery studies.

From analysis of spiked tissue samples BNW calculated the percent recovery according to the following equation.

$$\% \text{ recovery} = \frac{\text{measured µg element}}{\text{spiked µg element}} \times 100\%$$

In this equation, measured µg element is the measured total µg of gallium or arsenic (measured concentration x total volume) in the spiked tissue samples

which contained no measurable endogenous amounts of gallium or arsenic. In the above equation for percent recovery, spiked µg element is the total µg of gallium or arsenic used in preparing the tissue spikes (based on prepared concentration of the spiking solution x volume). The above equation was employed only when correction for endogenous concentration was not required.

For samples in which the blank tissue contained significant amounts of the element of interest (arsenic in rat blood and zinc in testes), the following equation for percent recovery was employed.

$$\% \text{ recovery} = \frac{\text{measured µg/g element} - \text{endogenous µg/g element}}{\text{spiked µg/g element}} \times 100\%$$

In this equation, measured µg/g element and spiked µg/g element are the measured and spiked amounts of the elements of interest and endogenous µg/g element is the amount concentration of the element present in the blank samples (determined by analysis of blanks).

Calculated recoveries and percent relative standard deviations (for replicates) are reported for each tissue spike in Tables B.6 through B.12. With a few notable exceptions, recoveries from most tissues were generally in the range from 90-110% for Ga, As, and Zn. As shown in Tables B.6 and B.7, recoveries for gallium and arsenic from whole blood were acceptable, provided each of these elements was present at a concentration of at least 1 µg/g. However, when gallium and arsenic concentrations in blood were lower than approximately 1 µg/g recoveries were very low and precision was poor. As shown in Table B.11, arsenic recovery from testes was consistently low, showing good precision but a recovery of only ~80%.

2. Minimum Detectable Limit and Minimum Quantifiable Limit

The minimum detectable limit (MDL) was defined as the reagent blank concentration plus three times the standard deviation of the blank. The reagent blank contained all reagents employed in the normal preparation of the samples, with the exception of tissue. Reagent blanks were also analyzed in the presence of matrix modifier. During the method performance evaluation, the blank response (absorbance) was measured repeatedly and the response factor (concentration/absorbance) for the lowest standard was used to convert the measured blank response into concentration units (µg/l). From these data, the solution detection limit was calculated as the average blank concentration plus three times the standard deviation of the average blank concentration (µg/l). The MDL for tissue analyses was then calculated by multiplying the solution concentration detection limit (µg/l) by the minimum sample solution volume (liters). The result is expressed in units of µg of each element. MDL values were estimated for each element and tissue type and these values are reported in Table B.13.

The minimum quantifiable limit (MQL) was defined as the reagent blank concentration plus ten times the standard deviation of the blank. As described above, the blank response (absorbance) was measured repeatedly and the response factor was used to convert the measured blank response into concentration units (µg/l). From these data, the solution quantitation limit was calculated as the blank concentration plus 10 times the standard deviation of the blank concentration (µg/l). The MQL for tissue analyses was calculated by multiplying the solution quantitation limit (µg/l) by the minimum sample

TABLE B.6. Recovery of Gallium from Spiked Samples of Whole Blood[a].

Date	Replicate	Spiked Amount (µg)	% Recovery ± SD
8/31/89	3	0.1	36 ± 8
8/31/89	2	0.25	69 ± 6
8/31/89	2	0.5	78 ± 1
8/31/89	3	1.0	84 ± 1
9/6/89	2	1.0	98.2 ± 0.1
8/28/89	3	5.0	104 ± 5
8/2/89	3	5.0	110 ± 5
8/2/89	3	10.0	105 ± 2
8/2/89	3	20.0	102 ± 1
8/2/89	3	40.0	102 ± 2
8/28/89	3	40.0	99 ± 1
9/6/89	2	200.0	99 ± 4
		Average[b]:	100 ± 8

[a]All spiked samples consisted of approximately 1 g whole rat blood.
[b]Average calculated only for samples containing spikes that were greater than or equal to 1 µg/g.

TABLE B.7. Recovery of Arsenic from Spiked Samples of Whole Blood[a].

Date	Replicate	Spiked Amount (µg)	% Recovery ± SD
8/31/89	2	1.0	115 ± 7
9/6/89	2	1.0	23 ± 10
8/2/89	3	5.0	143 ± 12
8/28/89	2	5.0	109 ± 20
8/2/89	3	10.0	97 ± 5
8/2/89	3	20.0	97 ± 3
8/2/89	3	40.0	110 ± 2
8/28/89	2	40.0	95 ± 2
8/31/89	2	100.0	105 ± 2
8/31/89	2	200.0	107 ± 2
9/6/89	2	200.0	107 ± 3
		Average[b]:	107 ± 16

[a]All spiked samples consisted of approximately 1 gram whole rat blood.
[b]Average calculated only for samples containing spikes that were greater than 1 µg/g.

TABLE B.8. Recovery of Gallium from Spiked Samples of Rat Fetal Tissue[a] and Pregnant Female Uterine Contents[b].

Date	Replicate	Spiked Amount (µg)	% Recovery ± SD
10/5/89[b]	3	1.0	105 ± 5
8/2/89[a]	2	5.0	104 ± 2
10/5/89[b]	3	10.0	103 ± 1
		Average:	104 ± 3

[a]Spiked samples consisted of approximately 0.1 gram rat fetal tissue.
[b]Spiked samples consisted of approximately 1-2 grams of homogenized female uterine contents.

TABLE B.9. Recovery of Arsenic from Spiked Samples of Rat Fetal Tissue[a] and Pregnant Female Uterine Contents[b].

Date	Replicate	Spiked Amount (µg)	% Recovery ± SD
10/5/89[b]	3	1.0	105 ± 4
8/2/89[a]	2	5.0	100 ± 3
10/5/89[b]	3	10.0	89 ± 1
		Average:	98 ± 8

[a]Spiked samples consisted of approximately 0.1 rat fetal tissue.
[b]Spiked samples consisted of approximately 1-2 grams of homogenized female uterine contents.

TABLE B.10. Recovery of Gallium from Spiked Samples of Rat Testes[a].

Date	Replicate	Spiked Amount (µg)	% Recovery ± SD
10/18/89	2	0.5	103 ± 5
10/18/89	2	1.0	101 ± 3
9/21/89	3	1.0	113 ± 2
9/21/89	3	10.0	111 ± 2
		Average:	107 ± 6

[a]Spiked samples consisted of approximately 0.5 - 1.0 gram of homogenized rat testes.

TABLE B.11. Recovery of Arsenic from Spiked Samples of Rat Testes[a].

Date	Replicate	Spiked Amount (µg)	% Recovery ± SD
10/18/89	2	0.5	82 ± 4
10/18/89	2	1.0	78 ± 4
9/21/89	3	1.0	82 ± 4
9/21/89	3	10.0	88 ± 2
		Average:	83 ± 4

[a]Spiked samples consisted of approximately 0.5 - 1.0 gram of homogenized rat testes.

TABLE B.12. Recovery of Zinc from Spiked Samples of Rat Testes[a].

Date	Replicate	Spiked Amount (µg)	% Recovery ± SD
8/9/89	3	30.0	106 ± 2
8/11/89	3	30.0	107 ± 6
		Average:	106 ± 5

[a]Spiked samples consisted of approximately 1.5 grams rat testis or rat testes homogenate.

TABLE B.13. Minimum Detectable Limits (MDL) for Gallium, Arsenic and Zinc.

Tissue Type	MDL Ga (µg)	MDL As (µg)	MDL Zn (µg)
Female Rat/Whole Blood	0.06	1.26	--[a]
Male Rat/Whole Blood	0.05	0.52	--[a]
Rat/Fetal Tissue	0.06	0.01	--[a]
Rat/Uterine Contents	0.43	0.47	--[a]
Rat and Mouse/Testes	0.10	0.15	0.25

[a]Zinc was only measured in testes.

solution volume (liters). The result is expressed in units of µg of each element. MQL values were estimated for each element and tissue type and these values are reported in Table B.14.

C. Results

Results of gallium and arsenic determinations in whole blood from male and female rats are reported in Tables B.15 and B.16. Results of gallium and arsenic determinations in uterine contents and fetal tissues from female rats are reported in Table B.17. Gallium, arsenic, and zinc determinations in mouse and rat testes are reported in Table B.18.

Data reported in Table B.15 through Table B.18 are not corrected for endogenous amounts present in control animals. As discussed above, gallium and arsenic determinations in whole blood with concentrations less than 1 µg/g, as well as arsenic determinations in testes at all concentrations, showed low recoveries. Data in Tables B.15 through B.18 are not corrected for low recoveries of these elements.

Values reported in Table B.15 through Table B.18 which indicate less than a given value, are less than the indicated MDL. Values in parentheses were between the MDL and MQL. Values less than the MQL are subject to a high degree of uncertainty and must be interpreted accordingly.

During preliminary range-finding analyses in mouse blood, results indicated that the amounts of these two elements were below the detection limit in samples from all dose groups. Consequently, determinations of gallium and arsenic in mouse blood were not performed.

J.A. Dill, Sr. Research Scientist

6/7/90
Date

TABLE B.14. Minimum Quantifiable Limits for Gallium, Arsenic and Zinc.

Tissue Type	MQL Ga (µg)	MQL As (µg)	MQL Zn (µg)
Female Rat/Whole Blood	0.20	4.22	--[a]
Male Rat/Whole Blood	0.15	1.66	--[a]
Rat/Fetal Tissue	0.2	0.02	--[a]
Rat/Uterine Contents	1.22	1.48	--[a]
Rat and Mouse/Testes	0.29	0.45	0.97

[a]Zinc was only measured in testes.

TABLE B.15. Results of Gallium and Arsenic Determinations in Whole Blood from Male Rats.

Sample ID	Exposure Group	Weeks Post Exposure	Sample Weight (g)	µg/g Ga[a]	µg/g As[a]
1091	Control	0	0.959	<0.05	11.0
1098	Control	0	1.282	<0.05	11.5
1089	Control	0	0.978	<0.05	12.5
1085	10 mg/m^3	0	1.140	(0.08)	27.3
1087	10 mg/m^3	0	1.009	(0.11)	30.3
1081	10 mg/m^3	0	1.057	(0.14)	35.9
1079	37 mg/m^3	0	0.872	0.52	91.7
1080	37 mg/m^3	0	0.930	0.66	90.5
1084	37 mg/m^3	0	0.878	0.72	80.9
1086	75 mg/m^3	0	0.866	0.91	115.0
1090	75 mg/m^3	0	1.006	1.16	137.7
1092	75 mg/m^3	0	0.970	1.45	145.4
1097	75 mg/m^3	0	0.963	0.96	106.9

[a]Values reported as "less than" (<) were less than the MDL indicated. Values in parentheses are greater than MDL but less than MQL (0.15 µg Ga).

TABLE B.16. Results of Gallium and Arsenic Determinations in Whole Blood from Female Rats.

Sample ID	Exposure Dose Group	Time Point (dg)	Sample Weight (g)	µg/g Ga[a]	µg/g As[a]
390	Control	7	1.032	<0.06	10.5
439	Control	7	0.950	<0.06	11.9
404	Control	7	0.987	<0.06	10.9
414	10 mg/m^3	7	0.972	<0.06	13.8
385	10 mg/m^3	7	0.992	<0.06	16.4
452	10 mg/m^3	7	1.269	<0.06	13.1
365	37 mg/m^3	7	0.996	(0.11)	30.4
408	37 mg/m^3	7	0.998	(0.10)	26.9
485	37 mg/m^3	7	0.947	(0.16)	26.9
383	75 mg/m^3	7	1.006	0.26	44.6
386	75 mg/m^3	7	0.961	0.27	41.9
406	75 mg/m^3	7	1.040	0.29	37.8
489	Control	14	0.933	<0.06	9.8
455	Control	14	1.051	<0.06	8.8
468	Control	14	0.975	<0.06	10.3
479	10 mg/m^3	14	0.973	(0.07)	30.5
568	10 mg/m^3	14	0.988	(0.11)	39.6
453	10 mg/m^3	14	1.010	(0.12)	20.0
669	37 mg/m^3	14	0.990	0.40	79.7
636	37 mg/m^3	14	0.997	0.42	73.8
613	37 mg/m^3	14	0.977	0.51	77.5
409	75 mg/m^3	14	0.979	0.52	115.7
449	75 mg/m^3	14	0.982	0.56	116.5
567	75 mg/m^3	14	1.022	0.44	111.8
704	Control	20	0.972	<0.06	11.5
688	Control	20	0.937	<0.06	9.6
730	Control	20	0.930	<0.06	7.1
611	10 mg/m^3	20	1.018	(0.06)	49.0
664	10 mg/m^3	20	0.981	(0.07)	50.7
665	10 mg/m^3	20	1.000	0.28	60.1
680	37 mg/m^3	20	1.010	0.41	91.0
681	37 mg/m^3	20	0.962	0.53	75.4
690	37 mg/m^3	20	0.983	0.38	41.4
595	75 mg/m^3	20	0.972	0.46	162.8
622	75 mg/m^3	20	0.959	0.59	164.7
675	75 mg/m^3	20	1.014	0.52	170.5

[a]Values reported as "less than" (<) were less than the MDL indicated. Values in parentheses are greater than MDL but less than MQL (0.20 µg Ga).

TABLE B.17. Results of Gallium and Arsenic Determinations on Uterine Contents of Female Rats.

Sample ID	Exposure Group	Time Point (dg)	Sample Weight (g)	µg/g Ga[a]	µg/g As[a]
390	Control	7[b]	0.038	<0.43	<0.47
439	Control	7	0.110	<0.43	<0.47
404	Control	7	0.054	<0.43	<0.47
414	10 mg/m^3	7	0.133	<0.43	<0.47
385	10 mg/m^3	7	0.070	<0.43	<0.47
365	37 mg/m^3	7	0.031	<0.43	<0.47
408	37 mg/m^3	7	0.135	<0.43	<0.47
485	37 mg/m^3	7	0.079	<0.43	<0.47
383	75 mg/m^3	7	0.144	<0.43	<0.47
386	75 mg/m^3	7	0.090	<0.43	<0.47
406	75 mg/m^3	7	0.054	<0.43	<0.47
489	Control	14[b]	2.768	<0.43	<0.47
455	Control	14	0.521	<0.43	<0.47
468	Control	14	2.528	<0.43	<0.47
479	10 mg/m^3	14	3.521	<0.43	<0.47
568	10 mg/m^3	14	2.445	(0.20)	<0.47
453	10 mg/m^3	14	2.845	0.19	<0.47
669	37 mg/m^3	14	2.482	0.62	<0.47
636	37 mg/m^3	14	3.924	0.55	(0.26)
613	37 mg/m^3	14	2.674	0.62	(0.19)
409	75 mg/m^3	14	2.895	1.05	(0.35)
449	75 mg/m^3	14	2.621	0.55	(0.26)
567	75 mg/m^3	14	2.223	0.52	(0.11)
704	Control	20[c]	2.374	<0.43	<0.47
688	Control	20	2.056	<0.43	<0.47
730	Control	20	1.851	<0.43	<0.47
611	10 mg/m^3	20	2.003	(0.46)	(0.36)
664	10 mg/m^3	20	2.205	<0.43	(0.35)
680	37 mg/m^3	20	2.108	1.14	2.52
681	37 mg/m^3	20	1.948	0.95	1.27
690	37 mg/m^3	20	1.799	1.03	1.04
595	75 mg/m^3	20	2.170	1.16	2.70
622	75 mg/m^3	20	1.810	1.20	1.92
675	75 mg/m^3	20	2.204	1.08	1.86

[a]Values reported as "less than" (<) were less than the MDL indicated. Values in parentheses are greater than MDL but less than MQL (MQL for Ga is 1.22 µg and MQL for As is 1.48 µg).

[b]Samples from the 7- and 14-dg time points were uterine contents.

[c]Samples from the 20-dg time point were homogenized fetal tissue.

TABLE B.18. Results of Zinc, Gallium and Arsenic Determinations in Rat and Mouse Testes[a].

Sample ID	Dose Group	Sample Weight (g)	µg/g Zn	µg/g Ga[b]	µg/g As[b]
Mice:					
1008	Control	0.124	14.5	<0.10	<0.15
1014	Control	0.146	11.8	<0.10	<0.15
1015	Control	0.130	15.4	<0.10	<0.15
1004	1 mg/m^3	0.160	14.5	<0.10	<0.15
1006	1 mg/m^3	0.170	11.6	<0.10	<0.15
1021	1 mg/m^3	0.148	12.7	<0.10	<0.15
1009	10 mg/m^3	0.150	15.4	<0.10	<0.15
1010	10 mg/m^3	0.157	10.4	<0.10	<0.15
1017	10 mg/m^3	0.119	12.0	<0.10	<0.15
1002	37 mg/m^3	0.163	13.2	0.88	<0.15
1022	37 mg/m^3	0.155	14.2	<0.10	<0.15
1012	37 mg/m^3	0.158	--[c]	--[c]	--[c]
Rats:					
1091	Control	1.784	12.9	<0.10	<0.15
1098	Control	1.710	13.2	<0.10	<0.15
1112	Control	1.470	10.9	<0.10	<0.15
1085	10 mg/m^3	1.645	12.9	0.18	(0.17)
1087	10 mg/m^3	1.638	12.5	0.26	(0.17)
1094	10 mg/m^3	1.695	12.5	0.28	(0.22)
1079	37 mg/m^3	1.551	14.3	0.86	0.43
1080	37 mg/m^3	1.785	12.6	1.10	0.59
1084	37 mg/m^3	1.523	12.2	1.11	0.67
1090	75 mg/m^3	1.910	13.1	1.89	0.73
1092	75 mg/m^3	1.672	11.9	1.90	1.06
1097	75 mg/m^3	1.697	12.3	1.31	0.68

[a]All samples were taken immediately after exposure ended.
[b]Values reported as "less than" (<) were less than the MDL of 10 µg Ga and 0.15 µg As. Values in parenthesis are greater than MDL but less than the MQL of 0.29 µg Ga and 0.45 µg As.
[c]Sample was lost during preparation. No data available.

APPENDIX C

EXPOSURE DATA

Summation Equations
Concentration Data
Temperature Data
Relative Humidity Data
Exhaust Airflow Data
Exposure Operation Discussion Sheets
Chamber Uniformity Data

Summation Equations

SUMMATION EQUATIONS

Mean: $$\bar{X} = \frac{1}{n} \sum_{i=1}^{n} X_i$$

Standard Deviation:

$$S = \sqrt{\frac{\sum_{i=1}^{n} X_i^2 - \left(\sum_{i=1}^{n} X_i\right)^2 / n}{n-1}}$$

where:

X_i = individual reading of concentration, temperature or relative humidity

n = number of individual readings

The weekly and study means and standard deviations for concentration were derived from the daily means and standard deviations using the following equation.

Mean: $$\bar{X} = \frac{\sum_{j=1}^{K} (n_j)(\bar{X}_j)}{\sum_{j=1}^{K} n_j}$$

Standard Deviation:

$$S = \sqrt{\frac{\sum_{j=1}^{K} (n_j - 1)\ (S_j^2)}{\sum_{j=1}^{K} n_j - 1}}$$

where:

n_j = number of daily readings

$\bar{X}_j$ = daily mean

S_j = daily standard deviation

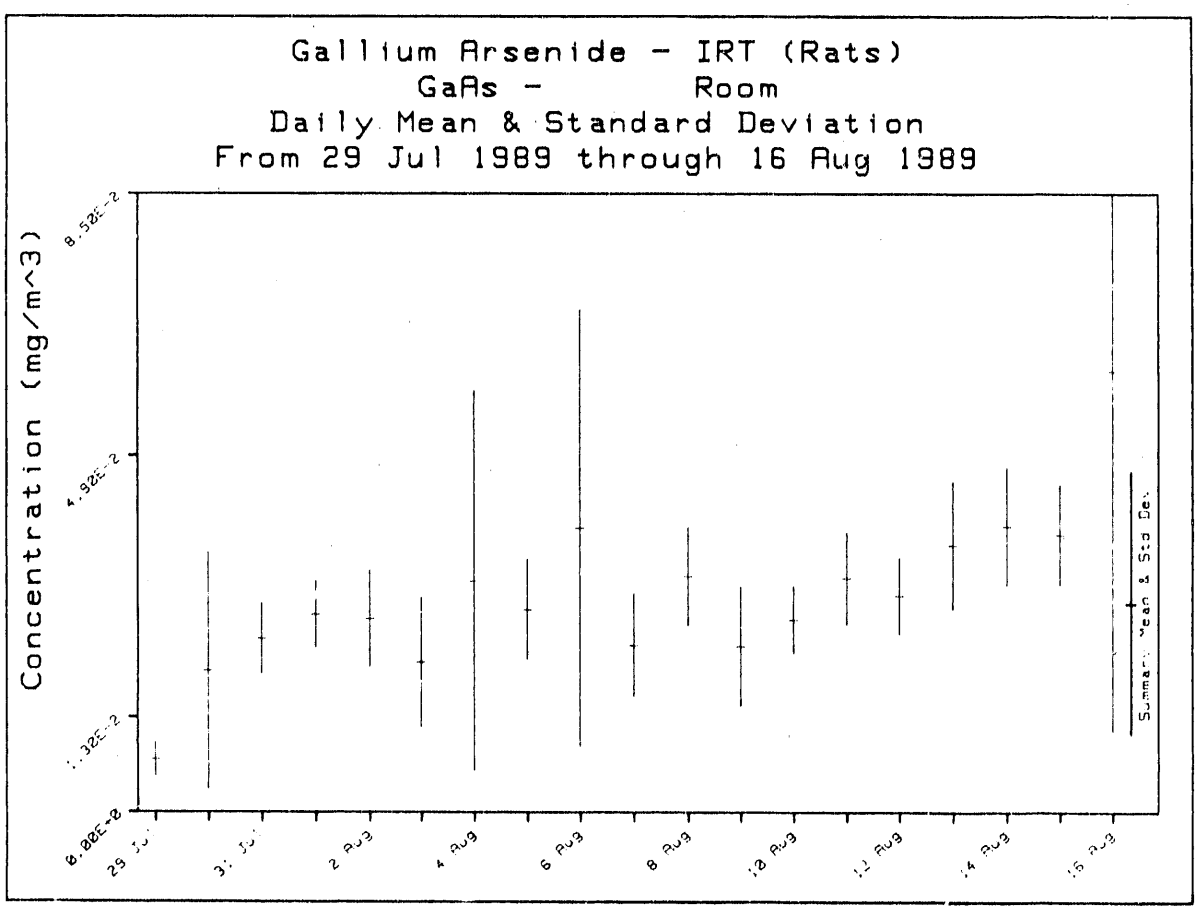
K = number of days included in summations

Concentration Data

Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - Room /Concentration Range=0.00E+0 to 1.30E-2

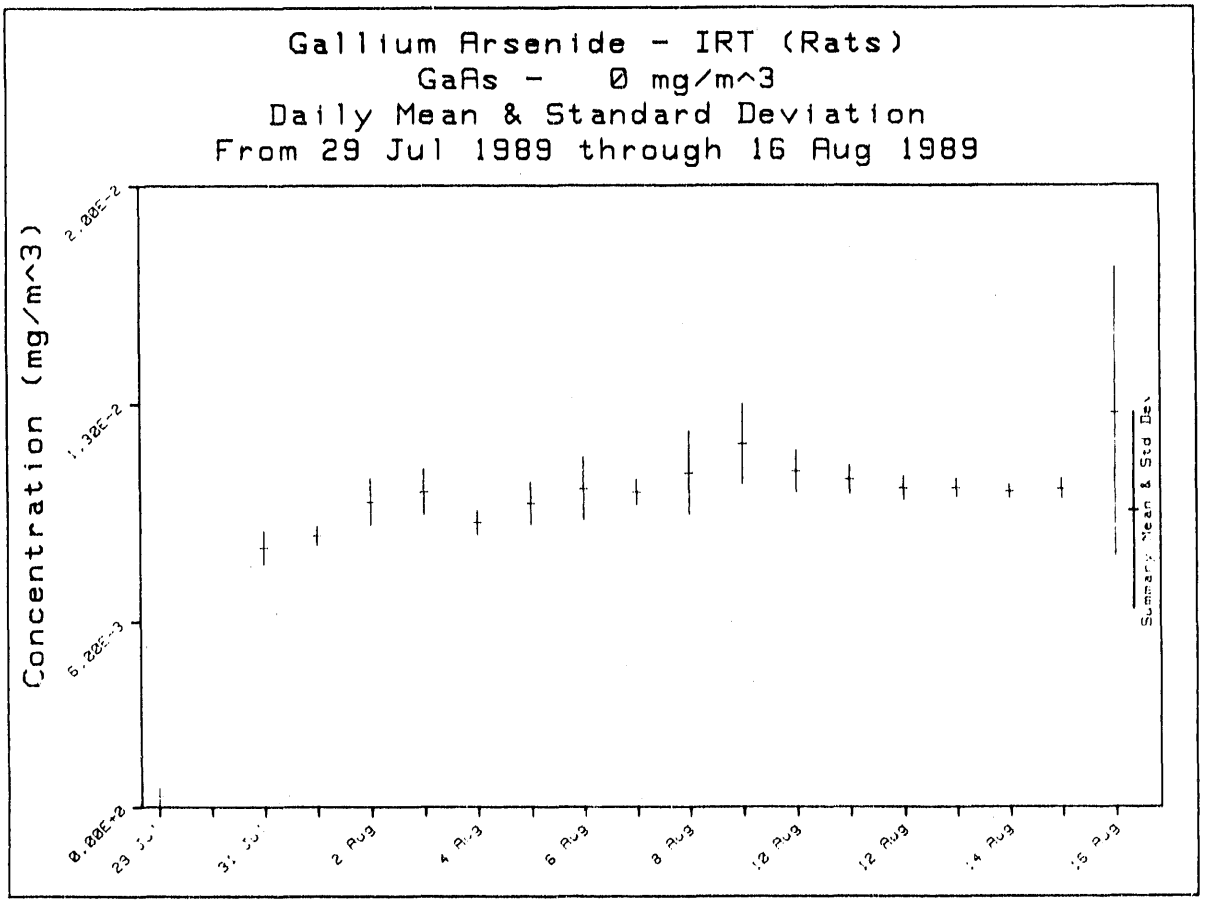
Date	Mean	Std Dev	Maximum	Minimum	N	N in	% N in
29 Jul 1989	7.18E-03	2.345E-03	1.05E-02	2.71E-03	9	9	100.0%
30 Jul 1989	1.94E-02	1.625E-02	6.89E-02	1.41E-03	13	5	38.5%
31 Jul 1989	2.39E-02	4.836E-03	3.34E-02	1.46E-02	11	0	0.0%
1 Aug 1989	2.73E-02	4.556E-03	3.68E-02	2.05E-02	11	0	0.0%
2 Aug 1989	2.66E-02	6.618E-03	3.62E-02	1.64E-02	14	0	0.0%
3 Aug 1989	2.06E-02	8.873E-03	5.61E-02	1.35E-02	33	0	0.0%
4 Aug 1989	3.18E-02	2.607E-02	1.27E-01	1.69E-02	16	0	0.0%
5 Aug 1989	2.79E-02	6.894E-03	4.99E-02	2.09E-02	14	0	0.0%
6 Aug 1989	3.90E-02	2.999E-02	1.28E-01	1.67E-02	16	0	0.0%
7 Aug 1989	2.30E-02	7.049E-03	3.66E-02	1.48E-02	18	0	0.0%
8 Aug 1989	3.24E-02	6.631E-03	3.94E-02	1.87E-02	13	0	0.0%
9 Aug 1989	2.28E-02	8.171E-03	4.55E-02	1.59E-02	34	0	0.0%
10 Aug 1989	2.65E-02	4.559E-03	3.23E-02	1.70E-02	13	0	0.0%
11 Aug 1989	3.22E-02	6.284E-03	4.09E-02	2.07E-02	11	0	0.0%
12 Aug 1989	2.98E-02	5.128E-03	3.82E-02	2.12E-02	12	0	0.0%
13 Aug 1989	3.67E-02	8.685E-03	5.81E-02	2.27E-02	12	0	0.0%
14 Aug 1989	3.93E-02	8.032E-03	5.33E-02	2.44E-02	13	0	0.0%
15 Aug 1989	3.81E-02	6.855E-03	4.65E-02	2.68E-02	12	0	0.0%
16 Aug 1989	6.05E-02	4.933E-02	1.80E-01	2.72E-02	12	0	0.0%
Summary	2.88E-02	1.790E-02	1.80E-01	1.41E-03	287	14	4.9%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 0 mg/m^3 /Concentration Range=0.00E+0 to 6.00E-3

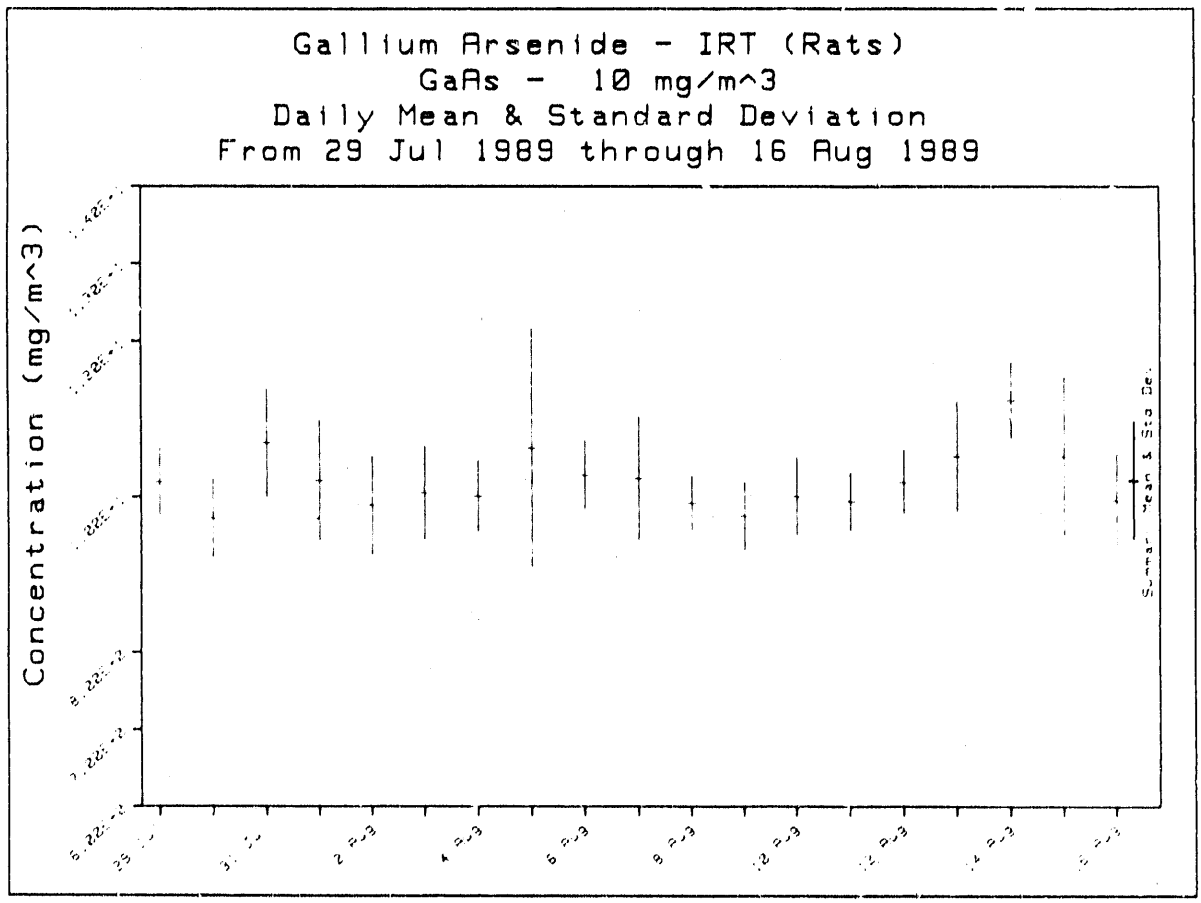
Date	Mean	Std Dev	Maximum	Minimum	N	N in	% N in
29 Jul 1989	3.39E-04	2.735E-04	6.67E-04	-3.37E-04	9	9	100.0%
30 Jul 1989	-3.61E-04	2.391E-04	1.65E-04	-7.03E-04	13	13	100.0%
31 Jul 1989	8.37E-03	5.296E-04	9.92E-03	7.93E-03	11	0	0.0%
1 Aug 1989	8.75E-03	2.945E-04	9.33E-03	8.28E-03	11	0	0.0%
2 Aug 1989	9.85E-03	7.558E-04	1.21E-02	9.04E-03	14	0	0.0%
3 Aug 1989	1.02E-02	7.439E-04	1.15E-02	8.64E-03	33	0	0.0%
4 Aug 1989	9.17E-03	3.814E-04	9.84E-03	8.68E-03	16	0	0.0%
5 Aug 1989	9.80E-03	6.791E-04	1.19E-02	9.28E-03	14	0	0.0%
6 Aug 1989	1.03E-02	1.007E-03	1.31E-02	9.37E-03	16	0	0.0%
7 Aug 1989	1.02E-02	4.097E-04	1.11E-02	9.54E-03	18	0	0.0%
8 Aug 1989	1.08E-02	1.340E-03	1.51E-02	9.80E-03	13	0	0.0%
9 Aug 1989	1.17E-02	1.277E-03	1.62E-02	1.03E-02	34	0	0.0%
10 Aug 1989	1.08E-02	6.668E-04	1.24E-02	1.00E-02	13	0	0.0%
11 Aug 1989	1.06E-02	4.499E-04	1.13E-02	1.01E-02	11	0	0.0%
12 Aug 1989	1.03E-02	3.725E-04	1.13E-02	9.90E-03	12	0	0.0%
13 Aug 1989	1.03E-02	2.972E-04	1.07E-02	9.80E-03	12	0	0.0%
14 Aug 1989	1.02E-02	2.150E-04	1.06E-02	9.84E-03	13	0	0.0%
15 Aug 1989	1.03E-02	3.407E-04	1.12E-02	9.88E-03	12	0	0.0%
16 Aug 1989	1.27E-02	4.614E-03	2.44E-02	9.76E-03	12	0	0.0%
Summary	9.56E-03	3.146E-03	2.44E-02	-7.03E-04	287	22	7.7%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 10 mg/m^3 /Concentration Range=8.00E+0 to 1.20E+1

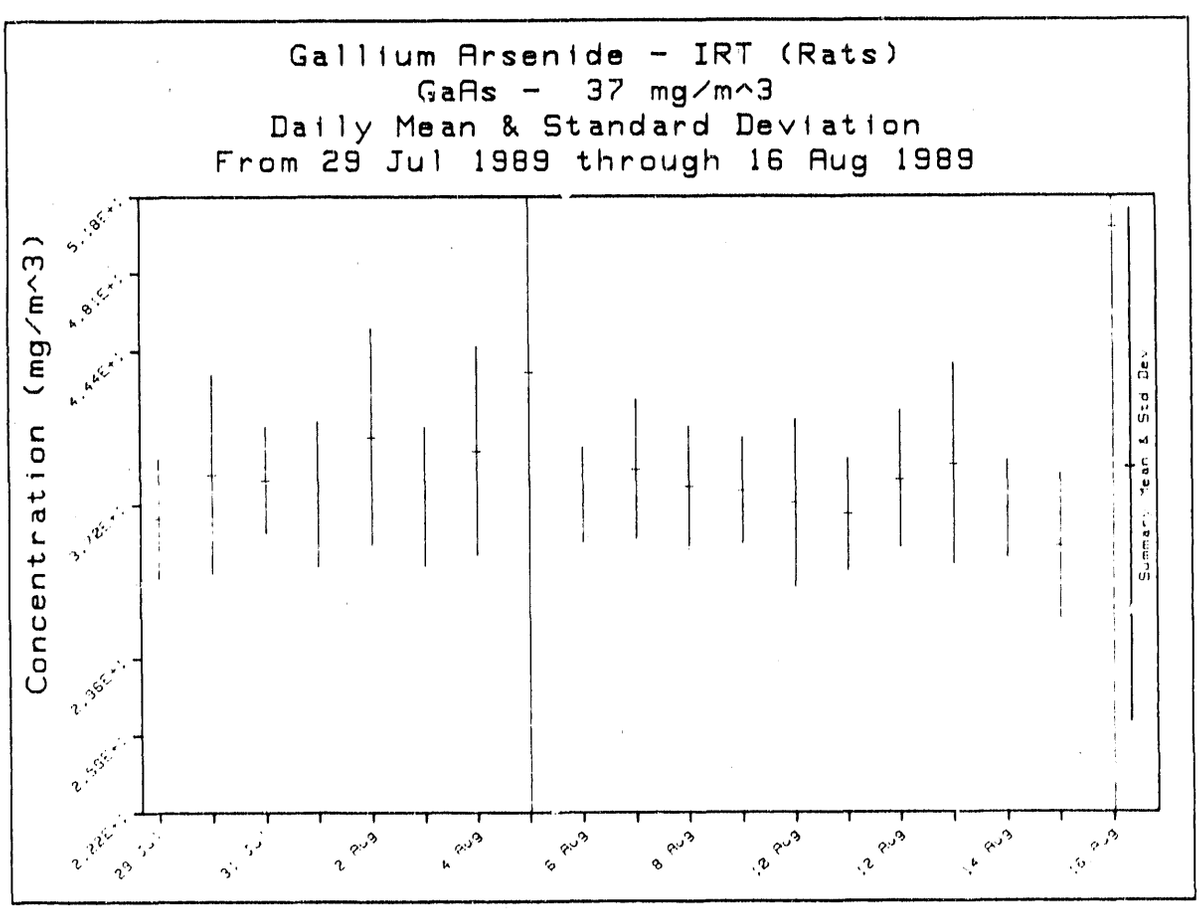
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	1.02E+01	102.0%	4.315E-01	4.2%	1.06E+01	9.39E+00	8	8	100.0%
30 Jul 1989	9.72E+00	97.2%	4.990E-01	5.1%	1.06E+01	8.97E+00	10	10	100.0%
31 Jul 1989	1.07E+01	106.9%	6.959E-01	6.5%	1.18E+01	9.76E+00	10	10	100.0%
1 Aug 1989	1.02E+01	102.1%	7.720E-01	7.6%	1.13E+01	8.95E+00	10	10	100.0%
2 Aug 1989	9.89E+00	98.9%	6.282E-01	6.4%	1.09E+01	8.67E+00	10	10	100.0%
3 Aug 1989	1.01E+01	100.5%	5.965E-01	5.9%	1.10E+01	9.39E+00	8	8	100.0%
4 Aug 1989	1.00E+01	100.1%	4.549E-01	4.5%	1.06E+01	9.31E+00	10	10	100.0%
5 Aug 1989	1.06E+01	106.3%	1.537E+00	14.5%	1.51E+01	9.37E+00	11	10	90.9%
6 Aug 1989	1.03E+01	102.8%	4.392E-01	4.3%	1.11E+01	9.27E+00	12	12	100.0%
7 Aug 1989	1.02E+01	102.4%	7.939E-01	7.8%	1.15E+01	9.22E+00	8	8	100.0%
8 Aug 1989	9.92E+00	99.2%	3.517E-01	3.5%	1.04E+01	9.35E+00	10	10	100.0%
9 Aug 1989	9.75E+00	97.5%	4.414E-01	4.5%	1.08E+01	9.26E+00	10	10	100.0%
10 Aug 1989	1.00E+01	100.1%	4.980E-01	5.0%	1.07E+01	9.39E+00	10	10	100.0%
11 Aug 1989	9.94E+00	99.4%	3.701E-01	3.7%	1.04E+01	9.15E+00	9	9	100.0%
12 Aug 1989	1.02E+01	101.9%	4.123E-01	4.0%	1.08E+01	9.51E+00	11	11	100.0%
13 Aug 1989	1.05E+01	105.2%	7.094E-01	6.7%	1.22E+01	9.65E+00	9	8	88.9%
14 Aug 1989	1.12E+01	112.4%	4.851E-01	4.3%	1.20E+01	1.04E+01	10	10	100.0%
15 Aug 1989	1.05E+01	105.2%	1.018E+00	9.7%	1.24E+01	9.29E+00	9	8	88.9%
16 Aug 1989	9.96E+00	99.6%	6.045E-01	6.1%	1.08E+01	9.26E+00	10	10	100.0%
Summary	1.02E+01	102.1%	7.456E-01	7.3%	1.51E+01	8.67E+00	185	182	98.4%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 37 mg/m^3 /Concentration Range=2.96E+1 to 4.44E+1

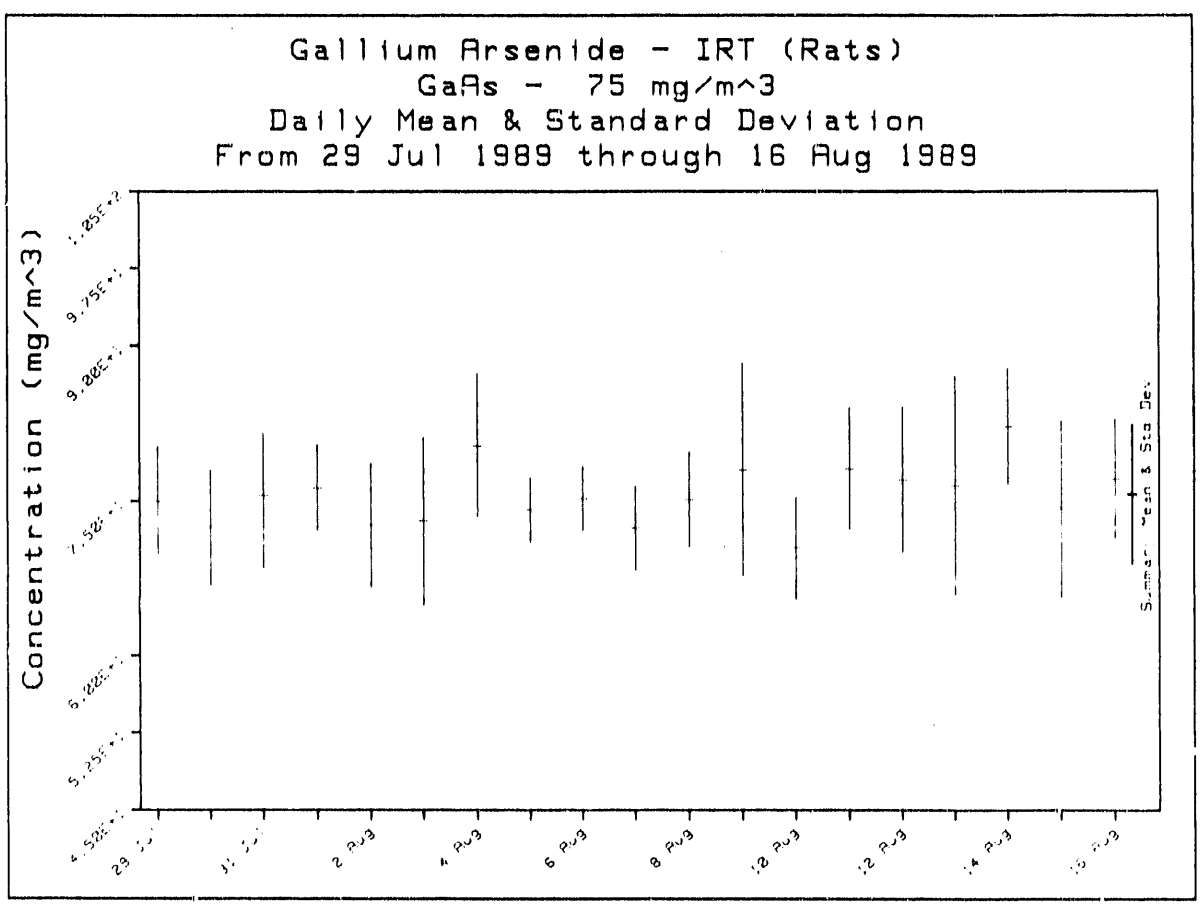
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	3.64E+01	98.3%	2.902E+00	8.0%	4.18E+01	3.33E+01	8	8	100.0%
30 Jul 1989	3.85E+01	104.0%	4.766E+00	12.4%	4.82E+01	3.39E+01	10	9	90.0%
31 Jul 1989	3.82E+01	103.3%	2.573E+00	6.7%	4.26E+01	3.43E+01	10	10	100.0%
1 Aug 1989	3.75E+01	101.5%	3.491E+00	9.3%	4.55E+01	3.20E+01	10	9	90.0%
2 Aug 1989	4.03E+01	108.9%	5.190E+00	12.9%	5.45E+01	3.61E+01	10	9	90.0%
3 Aug 1989	3.75E+01	101.2%	3.343E+00	8.9%	4.08E+01	3.25E+01	8	8	100.0%
4 Aug 1989	3.96E+01	107.0%	4.997E+00	12.6%	5.21E+01	3.34E+01	10	9	90.0%
5 Aug 1989	4.34E+01	117.2%	2.984E+01	68.8%	1.33E+02	2.87E+01	11	9	81.8%
6 Aug 1989	3.75E+01	101.4%	2.288E+00	6.1%	4.05E+01	3.39E+01	12	12	100.0%
7 Aug 1989	3.87E+01	104.7%	3.342E+00	8.6%	4.38E+01	3.48E+01	8	8	100.0%
8 Aug 1989	3.79E+01	102.5%	2.877E+00	7.6%	4.39E+01	3.51E+01	10	10	100.0%
9 Aug 1989	3.77E+01	101.9%	2.549E+00	6.8%	4.13E+01	3.44E+01	10	10	100.0%
10 Aug 1989	3.71E+01	100.3%	4.013E+00	10.8%	4.35E+01	3.16E+01	10	10	100.0%
11 Aug 1989	3.66E+01	98.8%	2.686E+00	7.3%	3.99E+01	3.07E+01	9	9	100.0%
12 Aug 1989	3.82E+01	103.4%	3.283E+00	8.6%	4.26E+01	3.31E+01	11	11	100.0%
13 Aug 1989	3.90E+01	105.3%	4.820E+00	12.4%	4.89E+01	3.42E+01	10	8	80.0%
14 Aug 1989	3.68E+01	99.5%	2.343E+00	6.4%	4.15E+01	3.30E+01	10	10	100.0%
15 Aug 1989	3.50E+01	94.7%	3.500E+00	10.0%	4.06E+01	2.94E+01	9	8	88.9%
16 Aug 1989	5.03E+01	135.9%	4.089E+01	81.3%	1.66E+02	3.09E+01	10	8	80.0%
Summary	3.88E+01	104.9%	1.226E+01	31.6%	1.66E+02	2.87E+01	186	175	94.1%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 75 mg/m^3 /Concentration Range=6.00E+1 to 9.00E+1

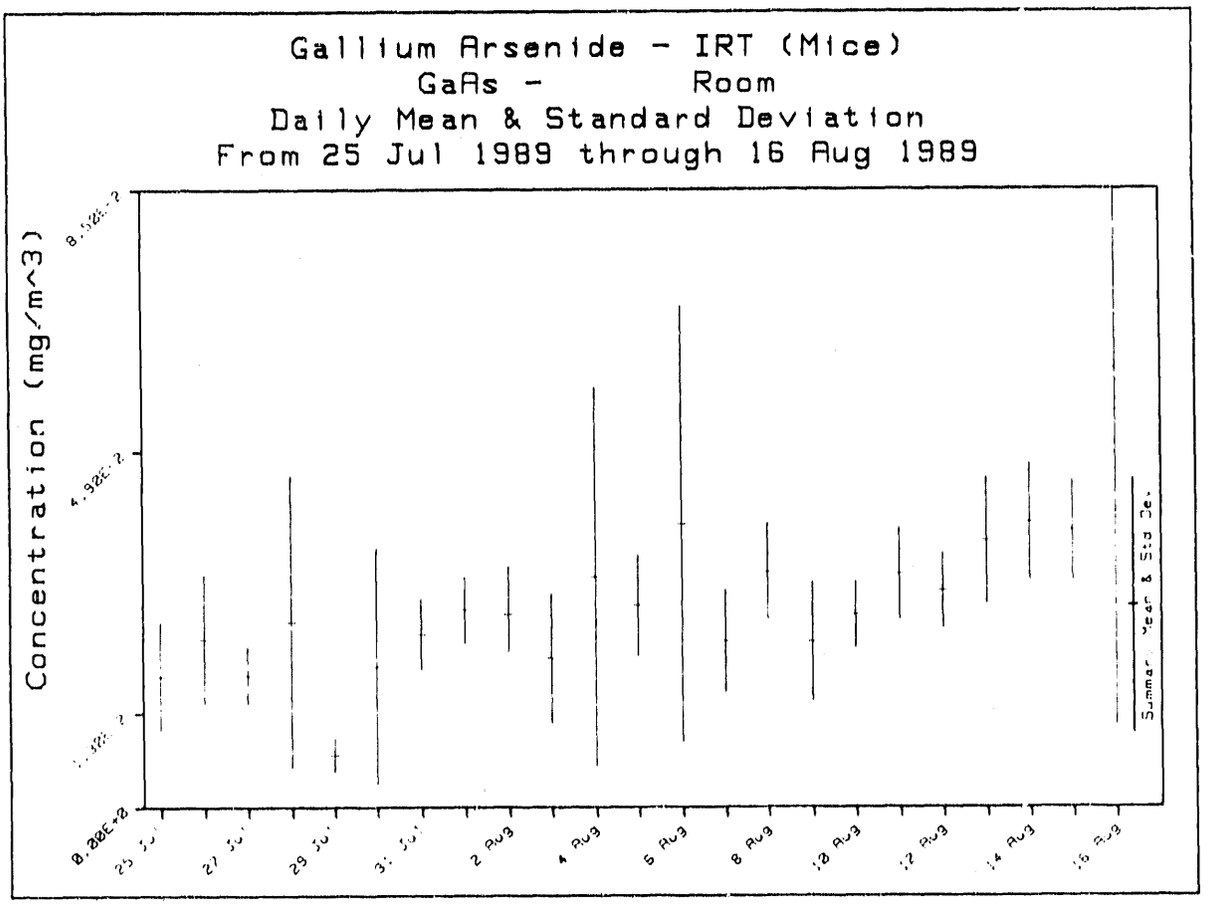
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	7.50E+01	100.0%	5.284E+00	7.0%	8.46E+01	6.92E+01	8	8	100.0%
30 Jul 1989	7.24E+01	96.6%	5.623E+00	7.8%	8.03E+01	6.04E+01	10	10	100.0%
31 Jul 1989	7.58E+01	100.8%	7.056E+00	9.3%	9.48E+01	7.05E+01	10	9	90.0%
1 Aug 1989	7.63E+01	101.7%	4.182E+00	5.5%	8.30E+01	6.99E+01	10	10	100.0%
2 Aug 1989	7.26E+01	96.9%	6.023E+00	8.3%	7.90E+01	6.07E+01	10	10	100.0%
3 Aug 1989	7.30E+01	97.4%	8.137E+00	11.1%	8.64E+01	6.25E+01	8	8	100.0%
4 Aug 1989	8.04E+01	107.2%	6.905E+00	8.6%	8.77E+01	6.70E+01	10	10	100.0%
5 Aug 1989	7.41E+01	98.8%	3.136E+00	4.2%	7.85E+01	6.99E+01	11	11	100.0%
6 Aug 1989	7.52E+01	100.3%	3.099E+00	4.1%	7.90E+01	6.87E+01	12	12	100.0%
7 Aug 1989	7.24E+01	96.5%	4.092E+00	5.7%	7.92E+01	6.90E+01	8	8	100.0%
8 Aug 1989	7.51E+01	100.2%	4.603E+00	6.1%	8.25E+01	6.85E+01	10	10	100.0%
9 Aug 1989	7.80E+01	104.1%	1.026E+01	13.1%	1.05E+02	7.07E+01	10	9	90.0%
10 Aug 1989	7.04E+01	93.9%	4.911E+00	7.0%	7.70E+01	6.39E+01	10	10	100.0%
11 Aug 1989	7.82E+01	104.2%	5.857E+00	7.5%	8.81E+01	6.71E+01	9	9	100.0%
12 Aug 1989	7.71E+01	102.8%	7.023E+00	9.1%	8.68E+01	6.44E+01	11	11	100.0%
13 Aug 1989	7.65E+01	102.0%	1.056E+01	13.8%	1.01E+02	6.72E+01	9	8	88.9%
14 Aug 1989	8.23E+01	109.7%	5.568E+00	6.8%	9.06E+01	7.38E+01	10	9	90.0%
15 Aug 1989	7.42E+01	99.0%	8.585E+00	11.6%	9.23E+01	6.55E+01	9	8	88.9%
16 Aug 1989	7.71E+01	102.9%	5.845E+00	7.6%	8.58E+01	6.82E+01	10	10	100.0%
Summary	7.58E+01	100.9%	6.719E+00	8.9%	1.05E+02	6.04E+01	185	180	97.3%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - Room /Concentration Range=0.00E+0 to 1.30E-2

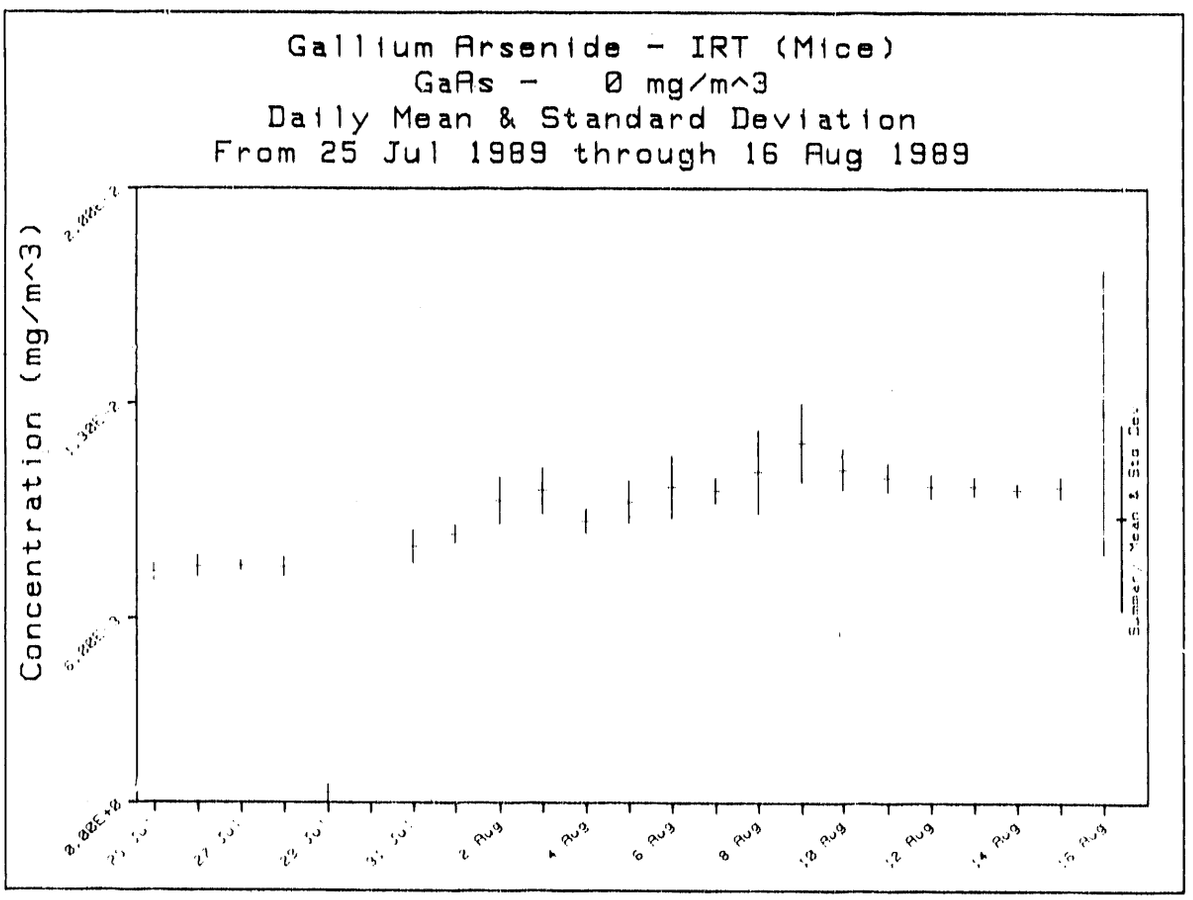
Date	Mean	Std Dev	Maximum	Minimum	N	N In	% N In
25 Jul 1989	1.82E-02	7.464E-03	2.79E-02	3.39E-03	14	2	14.3%
26 Jul 1989	2.33E-02	8.868E-03	3.73E-02	5.95E-03	11	1	9.1%
27 Jul 1989	1.83E-02	3.948E-03	2.76E-02	1.39E-02	12	0	0.0%
28 Jul 1989	2.56E-02	2.012E-02	8.75E-02	9.51E-03	12	1	8.3%
29 Jul 1989	7.18E-03	2.345E-03	1.05E-02	2.71E-03	9	9	100.0%
30 Jul 1989	1.94E-02	1.625E-02	6.89E-02	1.41E-03	13	5	38.5%
31 Jul 1989	2.39E-02	4.836E-03	3.34E-02	1.46E-02	11	0	0.0%
1 Aug 1989	2.73E-02	4.556E-03	3.68E-02	2.05E-02	11	0	0.0%
2 Aug 1989	2.66E-02	6.618E-03	3.62E-02	1.64E-02	14	0	0.0%
3 Aug 1989	2.06E-02	8.873E-03	5.61E-02	1.35E-02	33	0	0.0%
4 Aug 1989	3.18E-02	2.607E-02	1.27E-01	1.69E-02	16	0	0.0%
5 Aug 1989	2.79E-02	6.894E-03	4.99E-02	2.09E-02	14	0	0.0%
6 Aug 1989	3.90E-02	2.999E-02	1.28E-01	1.67E-02	16	0	0.0%
7 Aug 1989	2.30E-02	7.049E-03	3.66E-02	1.48E-02	18	0	0.0%
8 Aug 1989	3.24E-02	6.631E-03	3.94E-02	1.87E-02	13	0	0.0%
9 Aug 1989	2.28E-02	8.171E-03	4.55E-02	1.59E-02	34	0	0.0%
10 Aug 1989	2.65E-02	4.559E-03	3.23E-02	1.70E-02	13	0	0.0%
11 Aug 1989	3.22E-02	6.284E-03	4.09E-02	2.07E-02	11	0	0.0%
12 Aug 1989	2.98E-02	5.128E-03	3.82E-02	2.12E-02	12	0	0.0%
13 Aug 1989	3.67E-02	8.685E-03	5.81E-02	2.27E-02	12	0	0.0%
14 Aug 1989	3.93E-02	8.032E-03	5.33E-02	2.44E-02	13	0	0.0%
15 Aug 1989	3.81E-02	6.855E-03	4.65E-02	2.68E-02	12	0	0.0%
16 Aug 1989	6.05E-02	4.933E-02	1.80E-01	2.72E-02	12	0	0.0%
Summary	2.77E-02	1.734E-02	1.80E-01	1.41E-03	336	18	5.4%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 0 mg/m^3 /Concentration Range=0.00E+0 to 6.00E-3

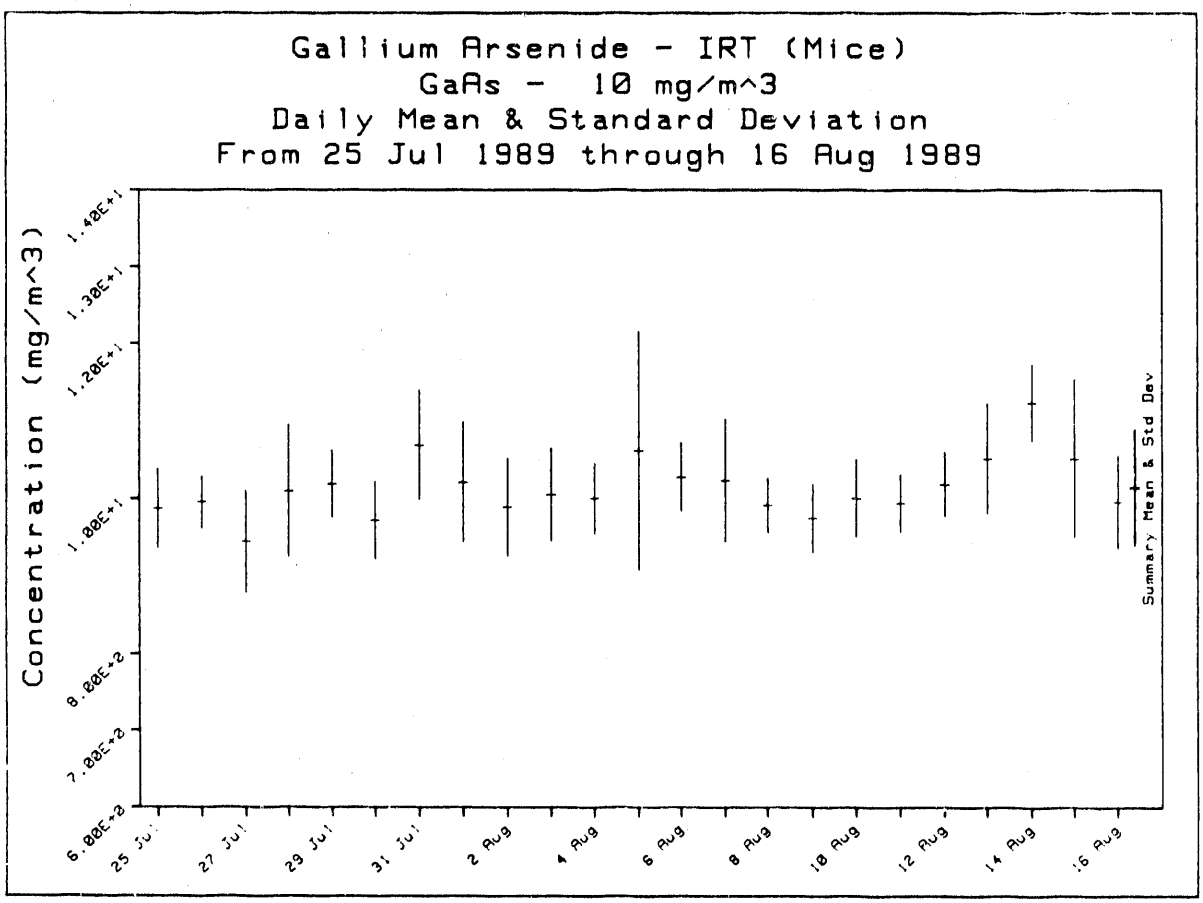
Date	Mean	Std Dev	Maximum	Minimum	N	N in	% N in
25 Jul 1989	7.51E-03	3.019E-04	7.94E-03	7.08E-03	14	0	0.0%
26 Jul 1989	7.70E-03	3.501E-04	8.29E-03	7.19E-03	11	0	0.0%
27 Jul 1989	7.72E-03	1.646E-04	8.10E-03	7.49E-03	12	0	0.0%
28 Jul 1989	7.68E-03	3.194E-04	8.35E-03	7.20E-03	12	0	0.0%
29 Jul 1989	3.39E-04	2.735E-04	6.67E-04	-3.37E-04	9	9	100.0%
30 Jul 1989	-3.61E-04	2.391E-04	1.65E-04	-7.03E-04	13	13	100.0%
31 Jul 1989	8.37E-03	5.296E-04	9.92E-03	7.93E-03	11	0	0.0%
1 Aug 1989	8.75E-03	2.945E-04	9.33E-03	8.28E-03	11	0	0.0%
2 Aug 1989	9.85E-03	7.558E-04	1.21E-02	9.04E-03	14	0	0.0%
3 Aug 1989	1.02E-02	7.439E-04	1.15E-02	8.64E-03	33	0	0.0%
4 Aug 1989	9.17E-03	3.814E-04	9.84E-03	8.68E-03	16	0	0.0%
5 Aug 1989	9.80E-03	6.791E-04	1.19E-02	9.28E-03	14	0	0.0%
6 Aug 1989	1.03E-02	1.007E-03	1.31E-02	9.37E-03	16	0	0.0%
7 Aug 1989	1.02E-02	4.097E-04	1.11E-02	9.54E-03	18	0	0.0%
8 Aug 1989	1.08E-02	1.340E-03	1.51E-02	9.80E-03	13	0	0.0%
9 Aug 1989	1.17E-02	1.277E-03	1.62E-02	1.03E-02	34	0	0.0%
10 Aug 1989	1.08E-02	6.868E-04	1.24E-02	1.00E-02	13	0	0.0%
11 Aug 1989	1.06E-02	4.499E-04	1.13E-02	1.01E-02	11	0	0.0%
12 Aug 1989	1.03E-02	3.725E-04	1.13E-02	9.90E-03	12	0	0.0%
13 Aug 1989	1.03E-02	2.972E-04	1.07E-02	9.80E-03	12	0	0.0%
14 Aug 1989	1.02E-02	2.150E-04	1.06E-02	9.84E-03	13	0	0.0%
15 Aug 1989	1.03E-02	3.407E-04	1.12E-02	9.88E-03	12	0	0.0%
16 Aug 1989	1.27E-02	4.614E-03	2.44E-02	9.76E-03	12	0	0.0%
Summary	9.28E-03	2.986E-03	2.44E-02	-7.03E-04	336	22	6.5%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 10 mg/m^3 /Concentration Range=8.00E+0 to 1.20E+1

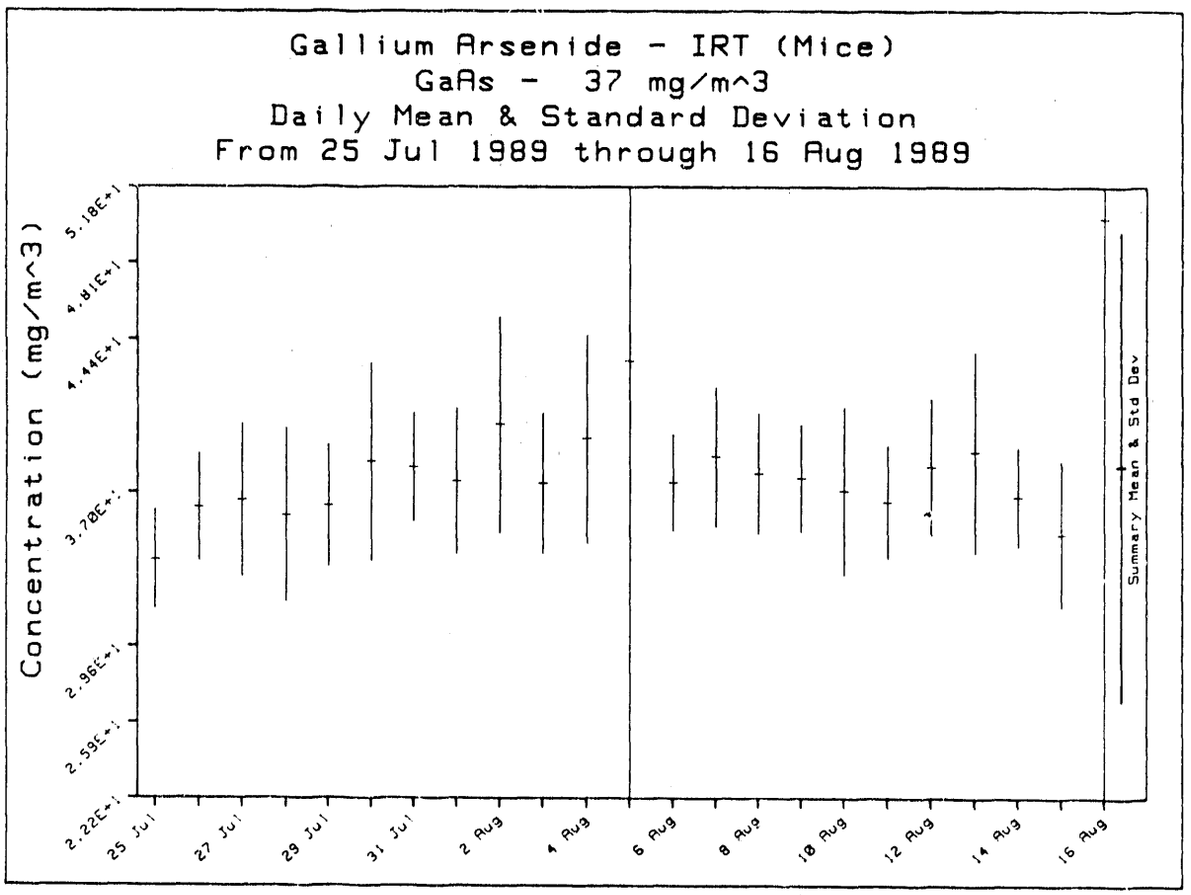
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	9.88E+00	98.8%	5.122E-01	5.2%	1.07E+01	9.18E+00	10	10	100.0%
26 Jul 1989	9.96E+00	99.6%	3.343E-01	3.4%	1.07E+01	9.63E+00	9	9	100.0%
27 Jul 1989	9.45E+00	94.5%	6.573E-01	7.0%	1.04E+01	8.32E+00	10	10	100.0%
28 Jul 1989	1.01E+01	101.0%	8.489E-01	8.4%	1.23E+01	9.42E+00	10	9	90.0%
29 Jul 1989	1.02E+01	102.0%	4.315E-01	4.2%	1.06E+01	9.39E+00	8	8	100.0%
30 Jul 1989	9.72E+00	97.2%	4.990E-01	5.1%	1.06E+01	8.97E+00	10	10	100.0%
31 Jul 1989	1.07E+01	106.9%	6.959E-01	6.5%	1.18E+01	9.76E+00	10	10	100.0%
1 Aug 1989	1.02E+01	102.1%	7.720E-01	7.6%	1.13E+01	8.95E+00	10	10	100.0%
2 Aug 1989	9.89E+00	98.9%	6.282E-01	6.4%	1.09E+01	8.67E+00	10	10	100.0%
3 Aug 1989	1.01E+01	100.5%	5.965E-01	5.9%	1.10E+01	9.39E+00	8	8	100.0%
4 Aug 1989	1.00E+01	100.1%	4.549E-01	4.5%	1.06E+01	9.31E+00	10	10	100.0%
5 Aug 1989	1.06E+01	106.3%	1.537E+00	14.5%	1.51E+01	9.37E+00	11	10	90.9%
6 Aug 1989	1.03E+01	102.8%	4.392E-01	4.3%	1.11E+01	9.27E+00	12	12	100.0%
7 Aug 1989	1.02E+01	102.4%	7.939E-01	7.8%	1.15E+01	9.22E+00	8	8	100.0%
8 Aug 1989	9.92E+00	99.2%	3.517E-01	3.5%	1.04E+01	9.35E+00	10	10	100.0%
9 Aug 1989	9.75E+00	97.5%	4.414E-01	4.5%	1.08E+01	9.26E+00	10	10	100.0%
10 Aug 1989	1.00E+01	100.1%	4.980E-01	5.0%	1.07E+01	9.39E+00	10	10	100.0%
11 Aug 1989	9.94E+00	99.4%	3.701E-01	3.7%	1.04E+01	9.15E+00	9	9	100.0%
12 Aug 1989	1.02E+01	101.9%	4.123E-01	4.0%	1.08E+01	9.51E+00	11	11	100.0%
13 Aug 1989	1.05E+01	105.2%	7.094E-01	6.7%	1.22E+01	9.65E+00	9	8	88.9%
14 Aug 1989	1.12E+01	112.4%	4.851E-01	4.3%	1.20E+01	1.04E+01	10	10	100.0%
15 Aug 1989	1.05E+01	105.2%	1.018E+00	9.7%	1.24E+01	9.29E+00	9	8	88.9%
16 Aug 1989	9.96E+00	99.6%	6.045E-01	6.1%	1.08E+01	9.26E+00	10	10	100.0%
Summary	1.01E+01	101.5%	7.415E-01	7.3%	1.51E+01	8.32E+00	224	220	98.2%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 37 mg/m^3 /Concentration Range=2.96E+1 to 4.44E+1

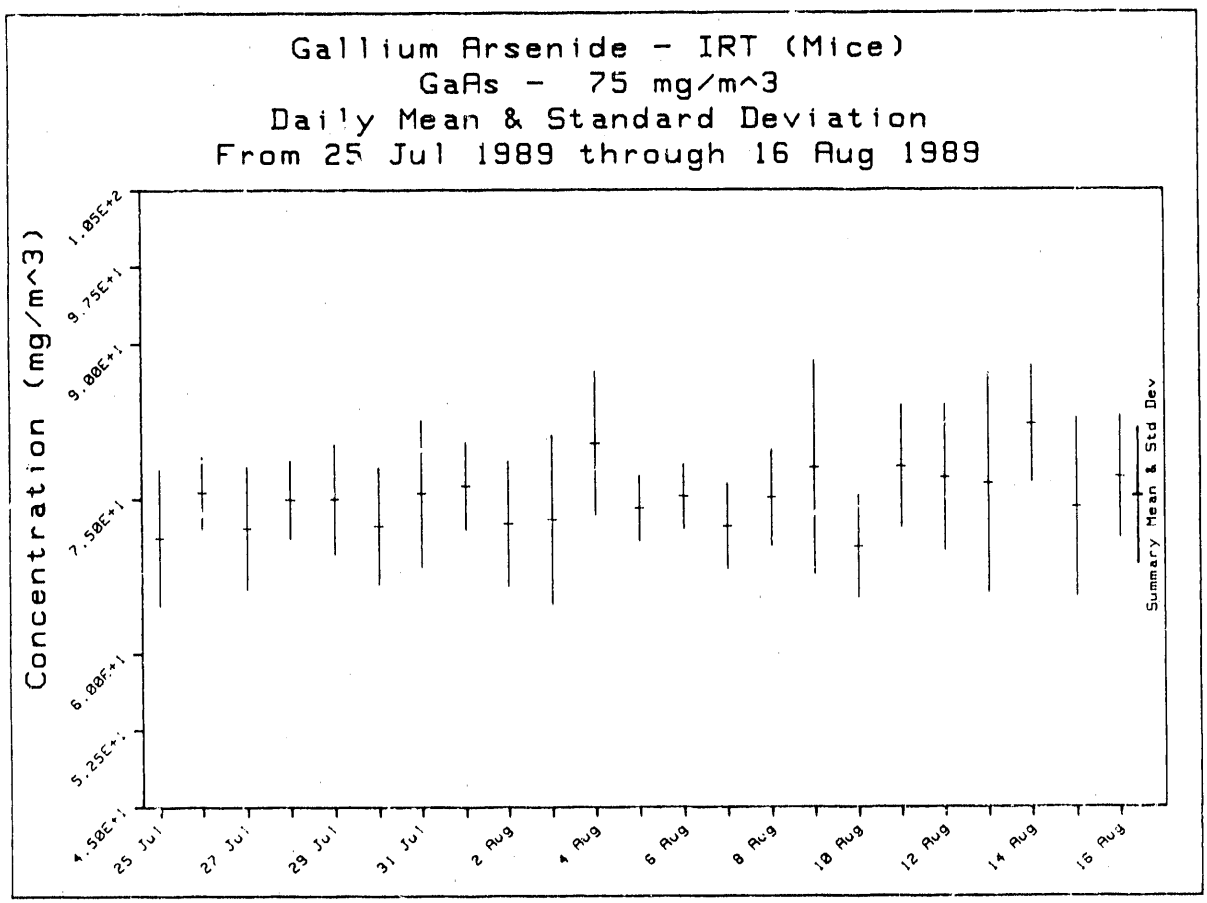
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	3.38E+01	91.3%	2.388E+00	7.1%	3.58E+01	2.73E+01	10	9	90.0%
26 Jul 1989	3.63E+01	98.1%	2.569E+00	7.1%	4.01E+01	3.20E+01	9	9	100.0%
27 Jul 1989	3.66E+01	99.0%	3.644E+00	9.9%	4.13E+01	2.85E+01	10	9	90.0%
28 Jul 1989	3.59E+01	97.1%	4.149E+00	11.5%	4.24E+01	2.59E+01	10	9	90.0%
29 Jul 1989	3.64E+01	98.3%	2.902E+00	8.0%	4.18E+01	3.33E+01	8	8	100.0%
30 Jul 1989	3.85E+01	104.0%	4.766E+00	12.4%	4.82E+01	3.39E+01	10	9	90.0%
31 Jul 1989	3.82E+01	103.3%	2.573E+00	6.7%	4.26E+01	3.43E+01	10	10	100.0%
1 Aug 1989	3.75E+01	101.5%	3.491E+00	9.3%	4.55E+01	3.20E+01	10	9	90.0%
2 Aug 1989	4.03E+01	108.9%	5.190E+00	12.9%	5.45E+01	3.61E+01	10	9	90.0%
3 Aug 1989	3.75E+01	101.2%	3.343E+00	8.9%	4.08E+01	3.25E+01	8	8	100.0%
4 Aug 1989	3.96E+01	107.0%	4.997E+00	12.6%	5.21E+01	3.34E+01	10	9	90.0%
5 Aug 1989	4.34E+01	117.2%	2.984E+01	68.8%	1.33E+02	2.87E+01	11	9	81.8%
6 Aug 1989	3.75E+01	101.4%	2.288E+00	6.1%	4.05E+01	3.39E+01	12	12	100.0%
7 Aug 1989	3.87E+01	104.7%	3.342E+00	8.6%	4.38E+01	3.48E+01	8	8	100.0%
8 Aug 1989	3.79E+01	102.5%	2.877E+00	7.6%	4.39E+01	3.51E+01	10	10	100.0%
9 Aug 1989	3.77E+01	101.9%	2.549E+00	6.8%	4.13E+01	3.44E+01	10	10	100.0%
10 Aug 1989	3.71E+01	100.3%	4.013E+00	10.8%	4.35E+01	3.16E+01	10	10	100.0%
11 Aug 1989	3.66E+01	98.8%	2.686E+00	7.3%	3.99E+01	3.07E+01	9	9	100.0%
12 Aug 1989	3.82E+01	103.4%	3.283E+00	8.6%	4.26E+01	3.31E+01	11	11	100.0%
13 Aug 1989	3.90E+01	105.3%	4.820E+00	12.4%	4.89E+01	3.42E+01	10	8	80.0%
14 Aug 1989	3.68E+01	99.5%	2.343E+00	6.4%	4.15E+01	3.30E+01	10	10	100.0%
15 Aug 1989	3.50E+01	94.7%	3.500E+00	10.0%	4.06E+01	2.94E+01	9	8	88.9%
16 Aug 1989	5.03E+01	135.9%	4.089E+01	81.3%	1.66E+02	3.09E+01	10	8	80.0%
Summary	3.83E+01	103.5%	1.129E+01	29.5%	1.66E+02	2.59E+01	225	211	93.8%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 75 mg/m^3 /Concentration Range=6.00E+1 to 9.00E+1

Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	7.13E+01	95.1%	6.591E+00	9.2%	8.26E+01	6.20E+01	10	10	100.0%
26 Jul 1989	7.56E+01	100.8%	3.463E+00	4.6%	8.23E+01	7.20E+01	9	9	100.0%
27 Jul 1989	7.22E+01	96.3%	5.915E+00	8.2%	7.99E+01	6.13E+01	10	10	100.0%
28 Jul 1989	7.50E+01	100.0%	3.746E+00	5.0%	8.35E+01	6.89E+01	10	10	100.0%
29 Jul 1989	7.50E+01	100.0%	5.284E+00	7.0%	8.46E+01	6.92E+01	8	8	100.0%
30 Jul 1989	7.24E+01	96.6%	5.623E+00	7.8%	8.03E+01	6.04E+01	10	10	100.0%
31 Jul 1989	7.56E+01	100.8%	7.056E+00	9.3%	9.48E+01	7.05E+01	10	9	90.0%
1 Aug 1989	7.63E+01	101.7%	4.182E+00	5.5%	8.30E+01	6.99E+01	10	10	100.0%
2 Aug 1989	7.26E+01	96.9%	6.023E+00	8.3%	7.90E+01	6.07E+01	10	10	100.0%
3 Aug 1989	7.30E+01	97.4%	8.137E+00	11.1%	8.64E+01	6.25E+01	8	8	100.0%
4 Aug 1989	8.04E+01	107.2%	6.905E+00	8.6%	8.77E+01	6.70E+01	10	10	100.0%
5 Aug 1989	7.41E+01	98.8%	3.136E+00	4.2%	7.85E+01	6.99E+01	11	11	100.0%
6 Aug 1989	7.52E+01	100.3%	3.099E+00	4.1%	7.90E+01	6.87E+01	12	12	100.0%
7 Aug 1989	7.24E+01	96.5%	4.092E+00	5.7%	7.92E+01	6.90E+01	8	8	100.0%
8 Aug 1989	7.51E+01	100.2%	4.603E+00	6.1%	8.25E+01	6.85E+01	10	10	100.0%
9 Aug 1989	7.80E+01	104.1%	1.026E+01	13.1%	1.05E+02	7.07E+01	10	9	90.0%
10 Aug 1989	7.04E+01	93.9%	4.911E+00	7.0%	7.70E+01	6.39E+01	10	10	100.0%
11 Aug 1989	7.82E+01	104.2%	5.857E+00	7.5%	8.81E+01	6.71E+01	9	9	100.0%
12 Aug 1989	7.71E+01	102.8%	7.023E+00	9.1%	8.68E+01	6.44E+01	11	11	100.0%
13 Aug 1989	7.65E+01	102.0%	1.056E+01	13.8%	1.01E+02	6.72E+01	9	8	88.9%
14 Aug 1989	8.23E+01	109.7%	5.568E+00	6.8%	9.06E+01	7.38E+01	10	9	90.0%
15 Aug 1989	7.42E+01	99.0%	8.585E+00	11.6%	9.23E+01	6.55E+01	9	8	88.9%
16 Aug 1989	7.71E+01	102.9%	5.845E+00	7.6%	8.58E+01	6.82E+01	10	10	100.0%
Summary	7.53E+01	100.4%	6.531E+00	8.7%	1.05E+02	6.04E+01	224	219	97.8%

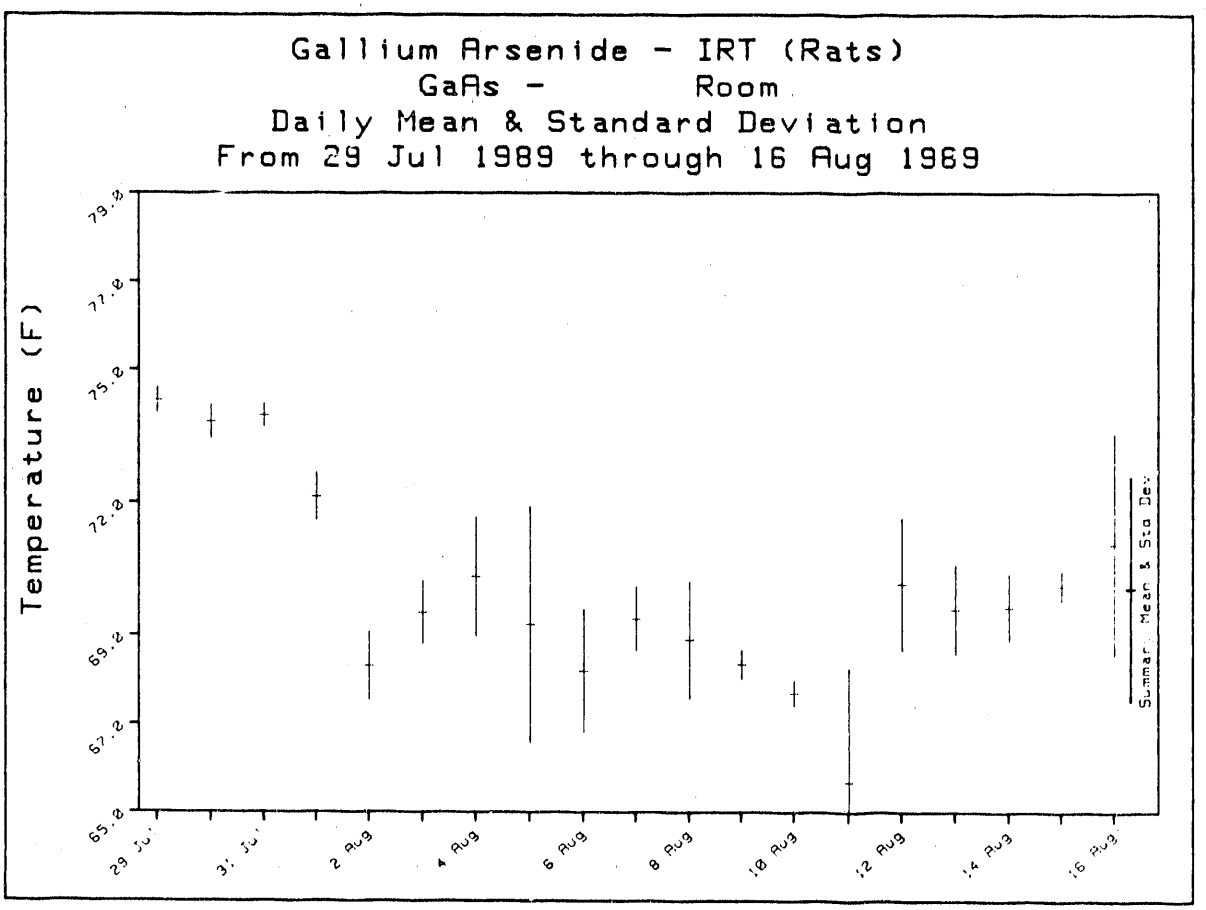


Temperature Data

Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - Room /Temperature Range= 69.0 to 75.0

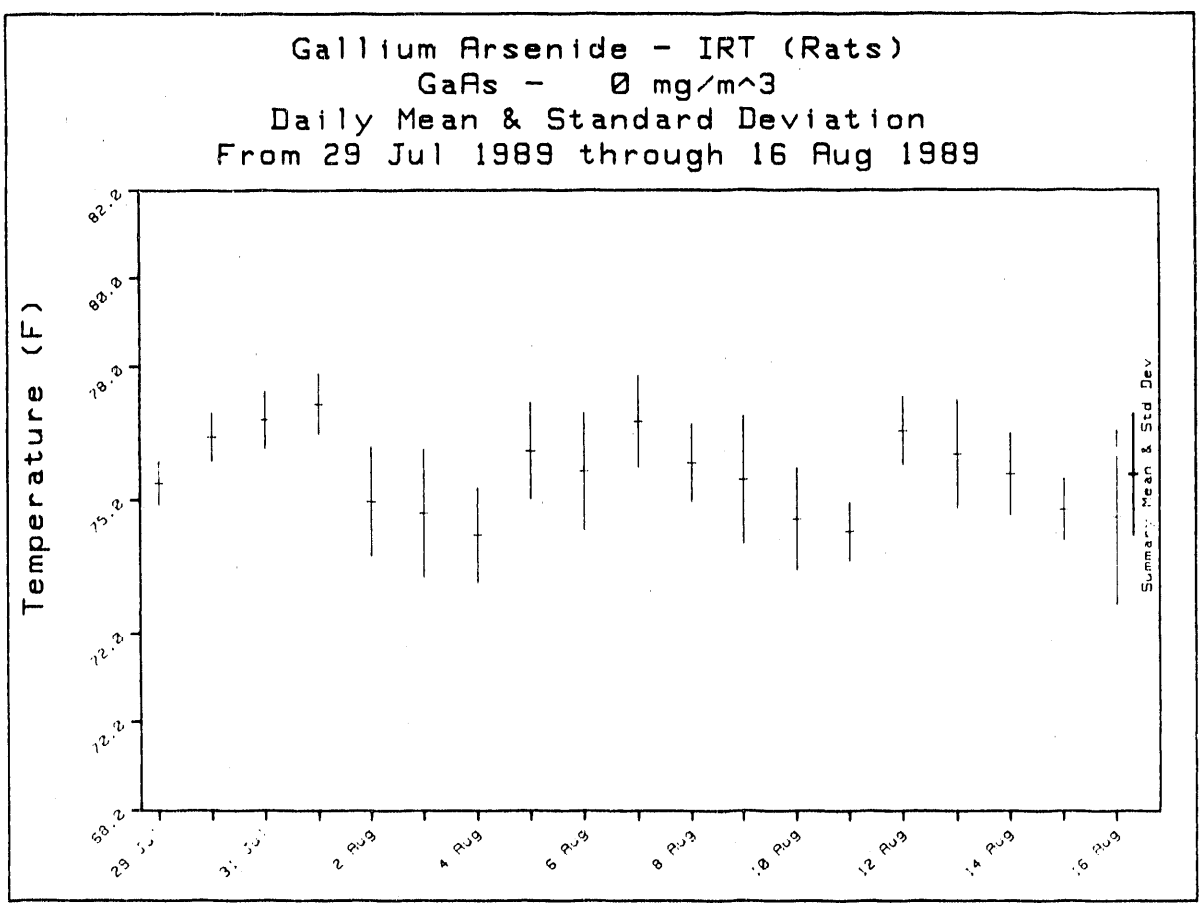
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	74.3	103.2%	.28	.4%	74.7	73.7	8	8	100.0%
30 Jul 1989	73.8	102.5%	.39	.5%	74.7	73.4	8	8	100.0%
31 Jul 1989	74.0	102.7%	.26	.4%	74.4	73.6	8	8	100.0%
1 Aug 1989	72.1	100.2%	.53	.7%	72.9	71.5	8	8	100.0%
2 Aug 1989	68.3	94.9%	.76	1.1%	69.3	67.4	8	2	25.0%
3 Aug 1989	69.5	96.6%	.71	1.0%	70.5	68.5	8	5	62.5%
4 Aug 1989	70.3	97.7%	1.34	1.9%	72.0	68.2	9	7	77.8%
5 Aug 1989	69.2	96.2%	2.66	3.8%	71.8	65.7	6	3	50.0%
6 Aug 1989	68.2	94.7%	1.39	2.0%	69.3	65.4	7	2	28.6%
7 Aug 1989	39.4	96.4%	.72	1.0%	70.4	68.6	8	5	62.5%
8 Aug 1989	68.9	95.7%	1.32	1.9%	71.8	67.7	8	3	37.5%
9 Aug 1989	68.3	94.9%	.32	.5%	68.8	67.8	8	0	0.0%
10 Aug 1989	67.7	94.0%	.28	.4%	68.1	67.4	8	0	0.0%
11 Aug 1989	65.7	91.2%	2.56	3.9%	71.1	63.4	8	1	12.5%
12 Aug 1989	70.2	97.4%	1.49	2.1%	73.1	69.1	6	6	100.0%
13 Aug 1989	69.6	96.6%	1.00	1.4%	70.6	67.6	8	6	75.0%
14 Aug 1989	69.6	96.7%	.75	1.1%	70.6	68.3	7	6	85.7%
15 Aug 1989	70.1	97.4%	.34	.5%	70.6	69.6	7	7	100.0%
16 Aug 1989	71.1	98.7%	2.51	3.5%	73.9	67.4	8	6	75.0%
Summary	70.0	97.3%	2.52	3.6%	74.7	63.4	146	91	62.3%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 0 mg/m^3 /Temperature Range= 72.0 to 78.0

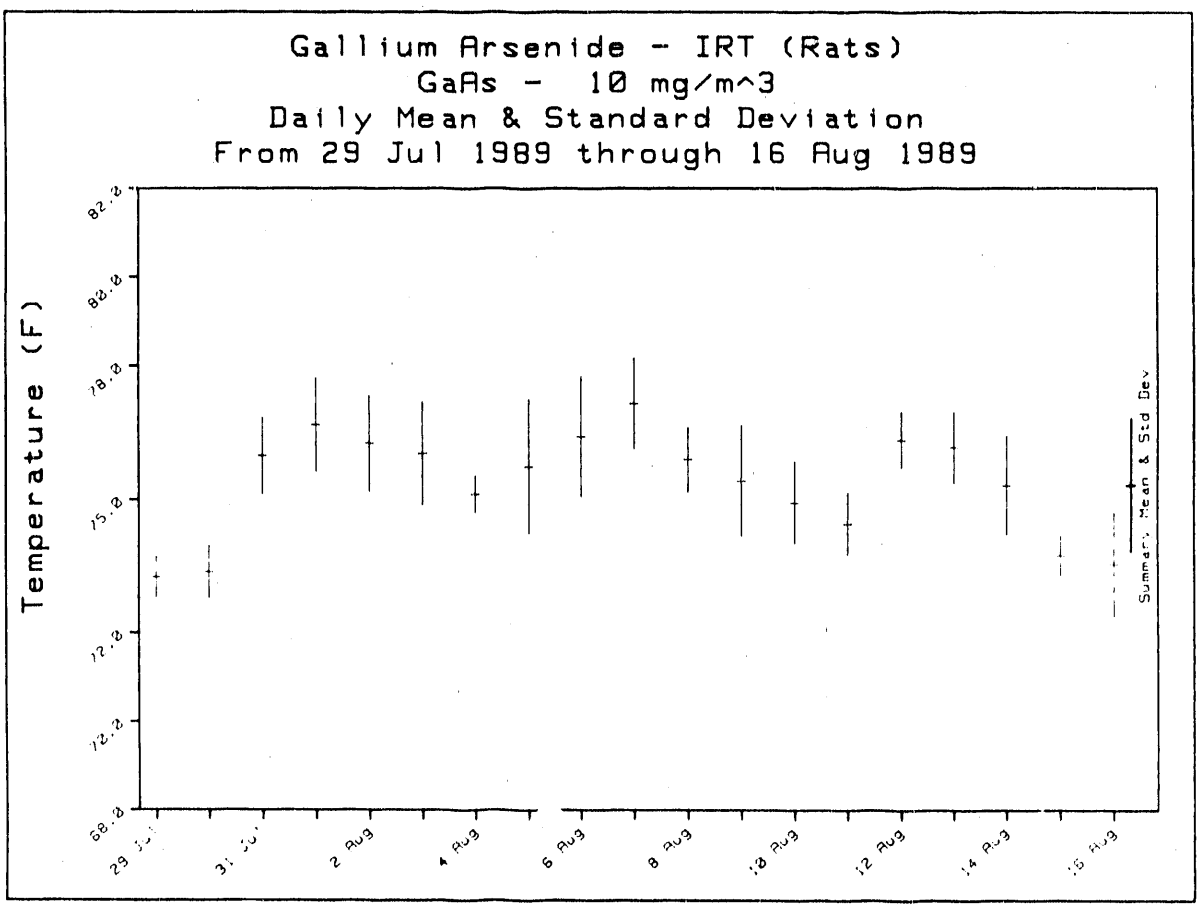
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	75.4	100.5%	.48	.6%	76.1	74.7	8	8	100.0%
30 Jul 1989	76.4	101.9%	.55	.7%	77.0	75.3	8	8	100.0%
31 Jul 1989	76.8	102.4%	.64	.8%	77.7	75.9	8	8	100.0%
1 Aug 1989	77.2	102.9%	.68	.9%	78.2	76.3	7	6	85.7%
2 Aug 1989	75.0	100.0%	1.23	1.6%	77.7	73.8	8	8	100.0%
3 Aug 1989	74.7	99.6%	1.43	1.9%	76.3	72.1	7	7	100.0%
4 Aug 1989	74.2	99.0%	1.06	1.4%	75.8	73.1	8	8	100.0%
5 Aug 1989	76.1	101.5%	1.09	1.4%	77.7	74.9	6	6	100.0%
6 Aug 1989	75.7	100.9%	1.32	1.7%	77.4	73.8	7	7	100.0%
7 Aug 1989	76.8	102.4%	1.02	1.3%	77.9	75.3	8	8	100.0%
8 Aug 1989	75.8	101.1%	.87	1.1%	76.8	74.8	6	6	100.0%
9 Aug 1989	75.5	100.6%	1.43	1.9%	77.5	73.8	7	7	100.0%
10 Aug 1989	74.6	99.4%	1.14	1.5%	76.4	73.2	8	8	100.0%
11 Aug 1989	74.3	99.1%	.65	.9%	75.3	73.5	7	7	100.0%
12 Aug 1989	76.6	102.1%	.76	1.0%	77.3	75.6	6	6	100.0%
13 Aug 1989	76.0	101.4%	1.22	1.6%	77.4	74.7	7	7	100.0%
14 Aug 1989	75.6	100.8%	.92	1.2%	77.3	74.7	6	6	100.0%
15 Aug 1989	74.8	99.7%	.70	.9%	75.4	73.9	6	6	100.0%
16 Aug 1989	74.6	99.5%	1.96	2.6%	76.7	71.7	8	7	87.5%
Summary	75.6	100.8%	1.35	1.8%	78.2	71.7	136	134	98.5%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 10 mg/m^3 /Temperature Range= 72.0 to 78.0

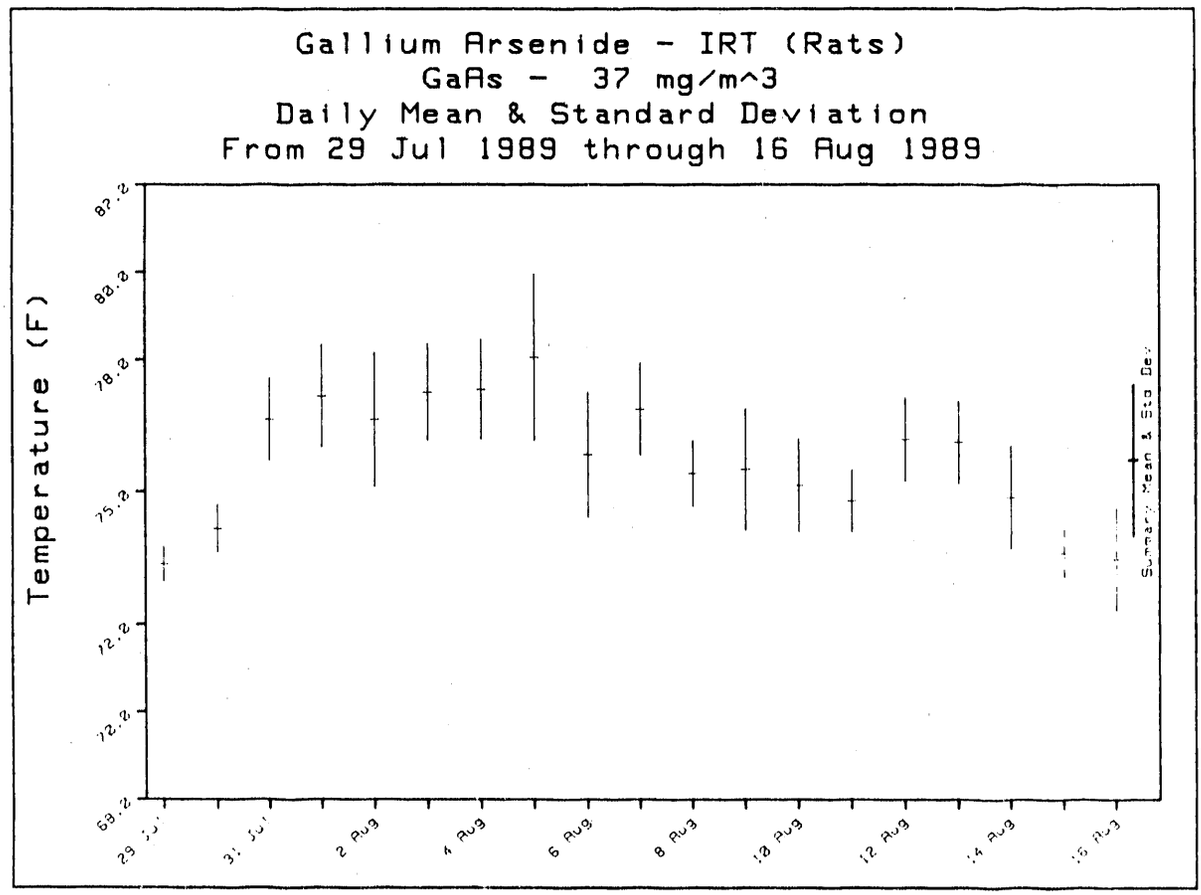
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	73.2	97.7%	.46	.6%	73.8	72.3	8	8	100.0%
30 Jul 1989	73.4	97.8%	.60	.8%	74.2	72.3	8	8	100.0%
31 Jul 1989	76.0	101.3%	.86	1.1%	76.7	74.0	8	8	100.0%
1 Aug 1989	76.7	102.2%	1.05	1.4%	78.0	75.2	7	6	85.7%
2 Aug 1989	76.3	101.7%	1.07	1.4%	77.7	74.6	8	8	100.0%
3 Aug 1989	76.0	101.4%	1.16	1.5%	77.2	73.7	7	7	100.0%
4 Aug 1989	75.1	100.2%	.41	.5%	75.5	74.5	8	8	100.0%
5 Aug 1989	75.7	101.0%	1.50	2.0%	78.3	74.1	6	5	83.3%
6 Aug 1989	76.4	101.9%	1.33	1.7%	78.1	74.5	7	6	85.7%
7 Aug 1989	77.2	102.9%	1.01	1.3%	78.2	75.6	8	6	75.0%
8 Aug 1989	75.9	101.2%	.72	.9%	76.8	75.0	6	6	100.0%
9 Aug 1989	75.4	100.6%	1.24	1.6%	77.5	73.9	7	7	100.0%
10 Aug 1989	74.9	99.9%	.92	1.2%	76.1	73.4	8	8	100.0%
11 Aug 1989	74.5	99.3%	.70	.9%	75.4	73.7	7	7	100.0%
12 Aug 1989	76.3	101.8%	.63	.8%	77.2	75.8	6	6	100.0%
13 Aug 1989	76.2	101.6%	.79	1.0%	77.1	75.0	7	7	100.0%
14 Aug 1989	75.3	100.4%	1.10	1.5%	77.1	74.0	6	6	100.0%
15 Aug 1989	73.7	98.3%	.45	.6%	74.1	73.1	6	6	100.0%
16 Aug 1989	73.5	98.1%	1.17	1.6%	74.9	71.5	8	7	87.5%
Summary	75.3	100.4%	1.47	2.0%	78.3	71.5	136	130	95.6%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 37 mg/m^3 /Temperature Range= 72.0 to 78.0

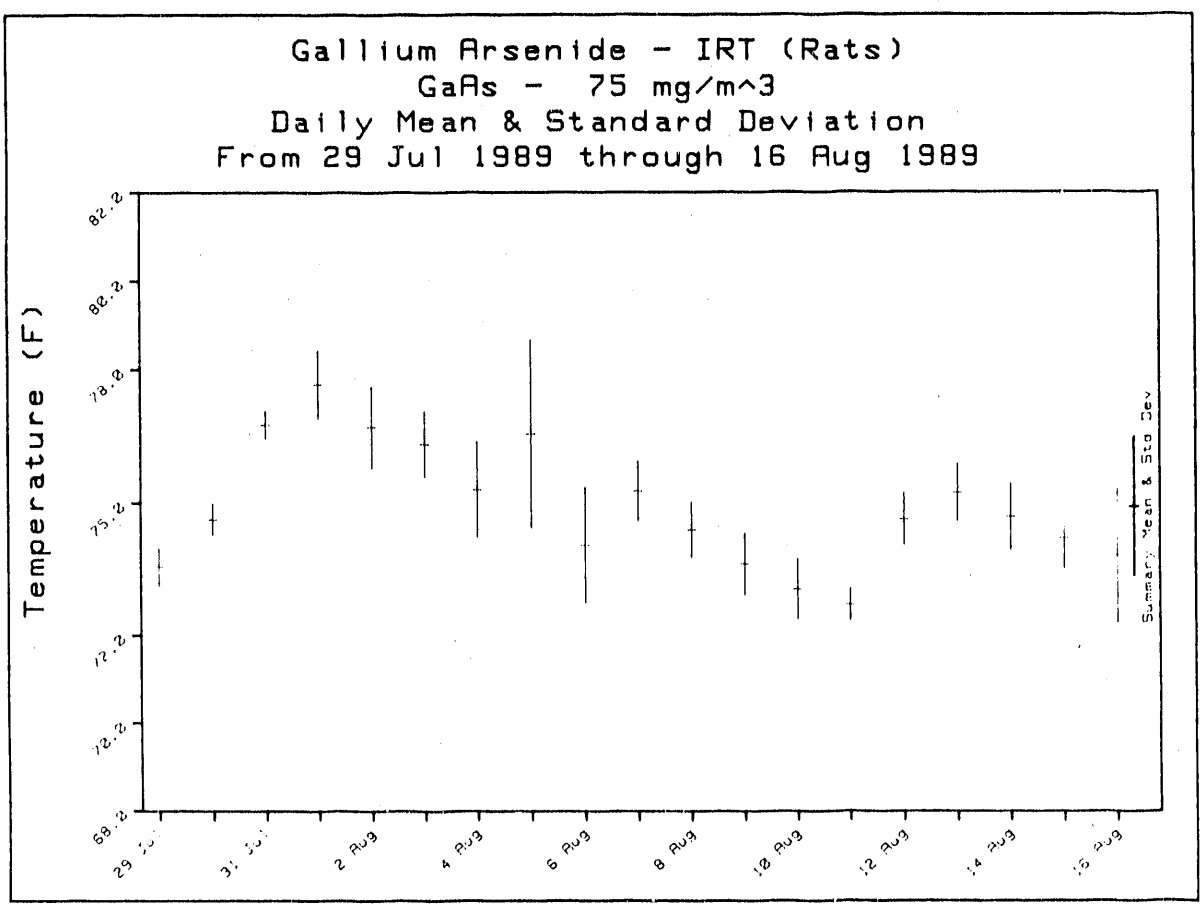
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	73.4	97.8%	.40	.5%	74.0	72.7	8	8	100.0%
30 Jul 1989	74.2	98.9%	.53	.7%	74.6	73.0	8	8	100.0%
31 Jul 1989	76.7	102.2%	.93	1.2%	77.5	74.5	8	8	100.0%
1 Aug 1989	77.2	102.9%	1.16	1.5%	78.5	75.7	7	4	57.1%
2 Aug 1989	76.6	102.2%	1.52	2.0%	79.1	74.6	8	7	87.5%
3 Aug 1989	77.3	103.0%	1.09	1.4%	78.4	75.8	8	5	62.5%
4 Aug 1989	77.3	103.1%	1.14	1.5%	78.9	76.0	8	5	62.5%
5 Aug 1989	78.1	104.1%	1.89	2.4%	80.0	74.5	6	2	33.3%
6 Aug 1989	75.8	101.1%	1.43	1.9%	77.6	73.7	7	7	100.0%
7 Aug 1989	76.9	102.5%	1.05	1.4%	78.0	75.5	8	7	87.5%
8 Aug 1989	75.4	100.6%	.75	1.0%	76.1	74.3	6	6	100.0%
9 Aug 1989	75.5	100.7%	1.38	1.8%	77.0	73.7	8	8	100.0%
10 Aug 1989	75.2	100.2%	1.05	1.4%	76.7	73.5	8	8	100.0%
11 Aug 1989	74.8	99.7%	.69	.9%	75.9	73.8	7	7	100.0%
12 Aug 1989	76.2	101.6%	.95	1.2%	77.2	74.8	6	6	100.0%
13 Aug 1989	76.1	101.5%	.94	1.2%	77.1	74.8	7	7	100.0%
14 Aug 1989	74.9	99.8%	1.16	1.6%	77.1	73.8	6	6	100.0%
15 Aug 1989	73.6	98.2%	.54	.7%	74.2	72.8	6	6	100.0%
16 Aug 1989	73.5	98.0%	1.16	1.6%	74.8	71.4	8	7	87.5%
Summary	75.7	101.0%	1.71	2.3%	80.0	71.4	138	122	88.4%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 75 mg/m^3 /Temperature Range= 72.0 to 78.0

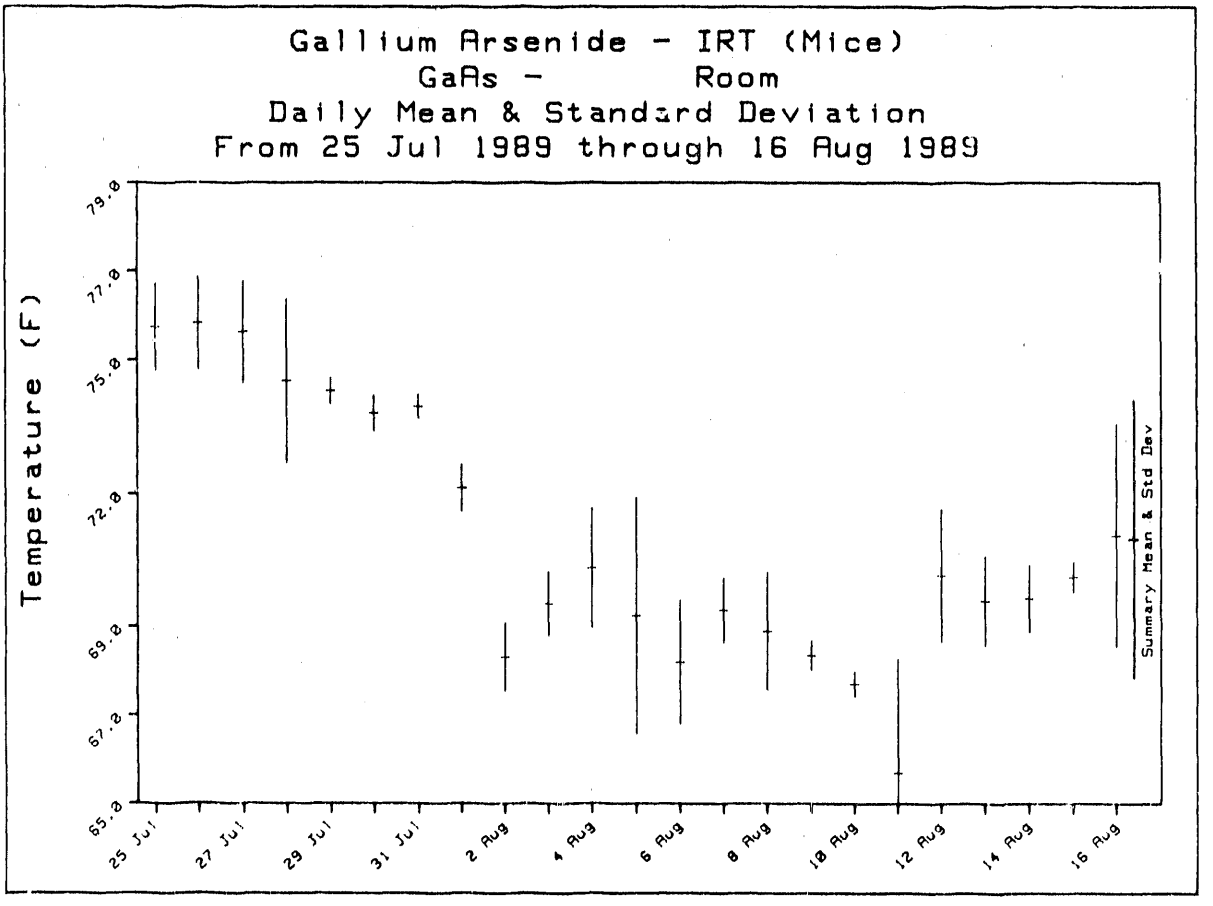
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	73.6	98.1%	.43	.6%	74.5	73.2	7	7	100.0%
30 Jul 1989	74.6	99.5%	.35	.5%	75.1	74.3	7	7	100.0%
31 Jul 1989	76.8	102.4%	.31	.4%	77.2	76.5	7	7	100.0%
1 Aug 1989	77.7	103.6%	.76	1.0%	78.6	77.0	6	4	66.7%
2 Aug 1989	76.7	102.3%	.91	1.2%	78.6	75.8	8	7	87.5%
3 Aug 1989	76.3	101.8%	.73	1.0%	77.2	75.2	7	7	100.0%
4 Aug 1989	75.3	100.4%	1.06	1.4%	76.3	73.5	8	8	100.0%
5 Aug 1989	76.6	102.1%	2.11	2.8%	78.7	73.2	5	4	80.0%
6 Aug 1989	74.1	98.7%	1.31	1.8%	75.6	71.9	7	6	85.7%
7 Aug 1989	75.3	100.4%	.67	.9%	76.1	74.5	8	8	100.0%
8 Aug 1989	74.4	99.2%	.62	.8%	75.4	73.4	7	7	100.0%
9 Aug 1989	73.6	98.2%	.70	1.0%	74.5	72.7	7	7	100.0%
10 Aug 1989	73.1	97.4%	.68	.9%	73.7	72.0	7	7	100.0%
11 Aug 1989	72.7	96.9%	.36	.5%	73.3	72.3	6	6	100.0%
12 Aug 1989	74.6	99.5%	.60	.8%	75.4	73.7	6	6	100.0%
13 Aug 1989	75.2	100.3%	.64	.9%	76.3	74.3	7	7	100.0%
14 Aug 1989	74.7	99.6%	.76	1.0%	76.1	73.9	6	6	100.0%
15 Aug 1989	74.2	98.9%	.69	.9%	74.8	73.2	6	6	100.0%
16 Aug 1989	73.8	98.4%	1.52	2.1%	75.6	71.7	7	6	85.7%
Summary	74.9	99.9%	1.56	2.1%	78.7	71.7	129	123	95.3%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - Room /Temperature Range= 69.0 to 75.0

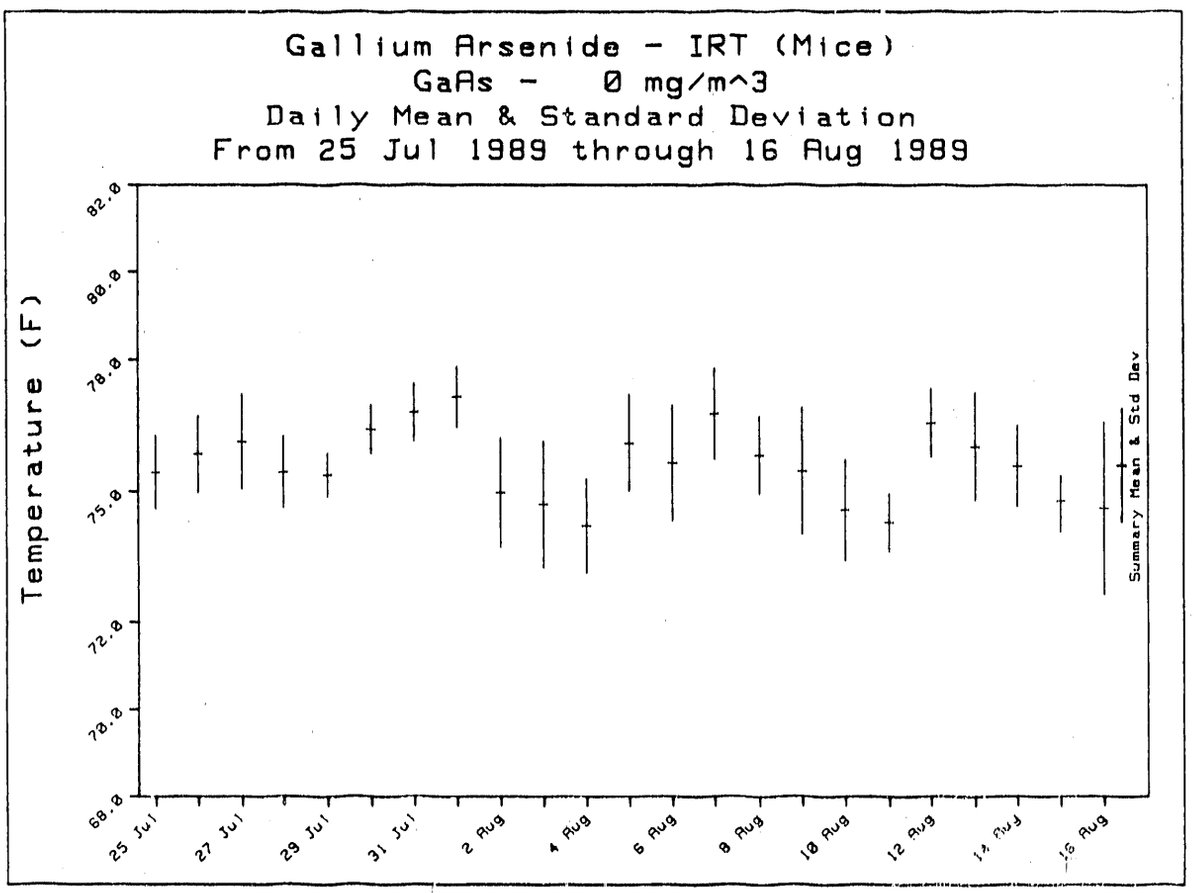
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	75.8	105.2%	.97	1.3%	77.4	74.4	6	1	16.7%
26 Jul 1989	75.8	105.3%	1.03	1.4%	77.5	74.7	8	3	37.5%
27 Jul 1989	75.6	105.0%	1.13	1.5%	78.2	74.5	9	3	33.3%
28 Jul 1989	74.5	103.5%	1.82	2.4%	77.7	72.4	7	5	71.4%
29 Jul 1989	74.3	103.2%	.28	.4%	74.7	73.7	8	8	100.0%
30 Jul 1989	73.8	102.5%	.39	.5%	74.7	73.4	8	8	100.0%
31 Jul 1989	74.0	102.7%	.26	.4%	74.4	73.6	8	8	100.0%
1 Aug 1989	72.1	100.2%	.53	.7%	72.9	71.5	8	8	100.0%
2 Aug 1989	68.3	94.9%	.76	1.1%	69.3	67.4	8	2	25.0%
3 Aug 1989	69.5	96.6%	.71	1.0%	70.5	68.5	8	5	62.5%
4 Aug 1989	70.3	97.7%	1.34	1.9%	72.0	68.2	9	7	77.8%
5 Aug 1989	69.2	96.2%	2.66	3.8%	71.8	65.7	6	3	50.0%
6 Aug 1989	68.2	94.7%	1.39	2.0%	69.3	65.4	7	2	28.6%
7 Aug 1989	69.4	96.4%	.72	1.0%	70.4	68.6	8	5	62.5%
8 Aug 1989	68.9	95.7%	1.32	1.9%	71.8	67.7	8	3	37.5%
9 Aug 1989	68.3	94.9%	.32	.5%	68.8	67.8	8	0	0.0%
10 Aug 1989	67.7	94.0%	.28	.4%	68.1	67.4	8	0	0.0%
11 Aug 1989	65.7	91.2%	2.56	3.9%	71.1	63.4	8	1	12.5%
12 Aug 1989	70.2	97.4%	1.49	2.1%	73.1	69.1	6	6	100.0%
13 Aug 1989	69.6	96.6%	1.00	1.4%	70.6	67.6	8	6	75.0%
14 Aug 1989	69.6	96.7%	.75	1.1%	70.6	68.3	7	6	85.7%
15 Aug 1989	70.1	97.4%	.34	.5%	70.6	69.6	7	7	100.0%
16 Aug 1989	71.1	98.7%	2.51	3.5%	73.9	67.4	8	6	75.0%
Summary	71.0	98.6%	3.11	4.4%	78.2	63.4	176	103	58.5%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 0 mg/m^3 /Temperature Range= 72.0 to 78.0

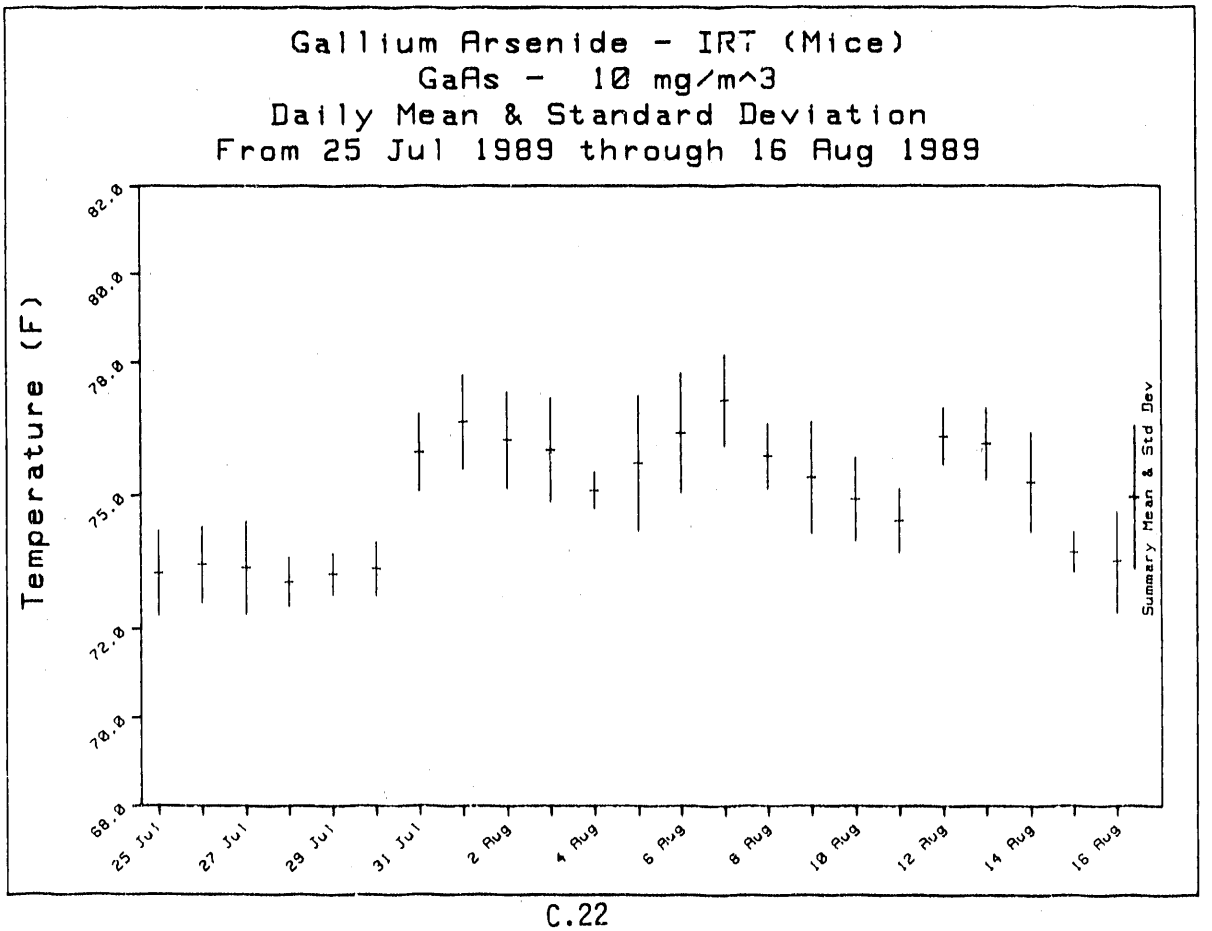
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	75.4	100.6%	.83	1.1%	76.5	74.5	6	6	100.0%
26 Jul 1989	75.9	101.1%	.87	1.1%	76.9	74.8	8	8	100.0%
27 Jul 1989	76.1	101.5%	1.08	1.4%	78.2	74.8	8	7	87.5%
28 Jul 1989	75.4	100.6%	.81	1.1%	76.9	74.8	8	8	100.0%
29 Jul 1989	75.4	100.5%	.48	.6%	76.1	74.7	8	8	100.0%
30 Jul 1989	76.4	101.9%	.55	.7%	77.0	75.3	8	8	100.0%
31 Jul 1989	76.8	102.4%	.64	.8%	77.7	75.9	8	8	100.0%
1 Aug 1989	77.2	102.9%	.68	.9%	78.2	76.3	7	6	85.7%
2 Aug 1989	75.0	100.0%	1.23	1.6%	77.7	73.8	8	8	100.0%
3 Aug 1989	74.7	99.6%	1.43	1.9%	76.3	72.1	7	7	100.0%
4 Aug 1989	74.2	99.0%	1.06	1.4%	75.8	73.1	8	8	100.0%
5 Aug 1989	76.1	101.5%	1.09	1.4%	77.7	74.9	6	6	100.0%
6 Aug 1989	75.7	100.9%	1.32	1.7%	77.4	73.8	7	7	100.0%
7 Aug 1989	76.8	102.4%	1.02	1.3%	77.9	75.3	8	8	100.0%
8 Aug 1989	75.8	101.1%	.87	1.1%	76.8	74.8	6	6	100.0%
9 Aug 1989	75.5	100.6%	1.43	1.9%	77.5	73.8	7	7	100.0%
10 Aug 1989	74.6	99.4%	1.14	1.5%	76.4	73.2	8	8	100.0%
11 Aug 1989	74.3	99.1%	.65	.9%	75.3	73.5	7	7	100.0%
12 Aug 1989	76.6	102.1%	.76	1.0%	77.3	75.6	6	6	100.0%
13 Aug 1989	76.0	101.4%	1.22	1.6%	77.4	74.7	7	7	100.0%
14 Aug 1989	75.6	100.8%	.92	1.2%	77.3	74.7	6	6	100.0%
15 Aug 1989	74.8	99.7%	.70	.9%	75.4	73.9	6	6	100.0%
16 Aug 1989	74.6	99.5%	1.96	2.6%	76.7	71.7	8	7	87.5%
Summary	75.6	100.8%	1.28	1.7%	78.2	71.7	166	163	98.2%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 10 mg/m^3 /Temperature Range= 72.0 to 78.0

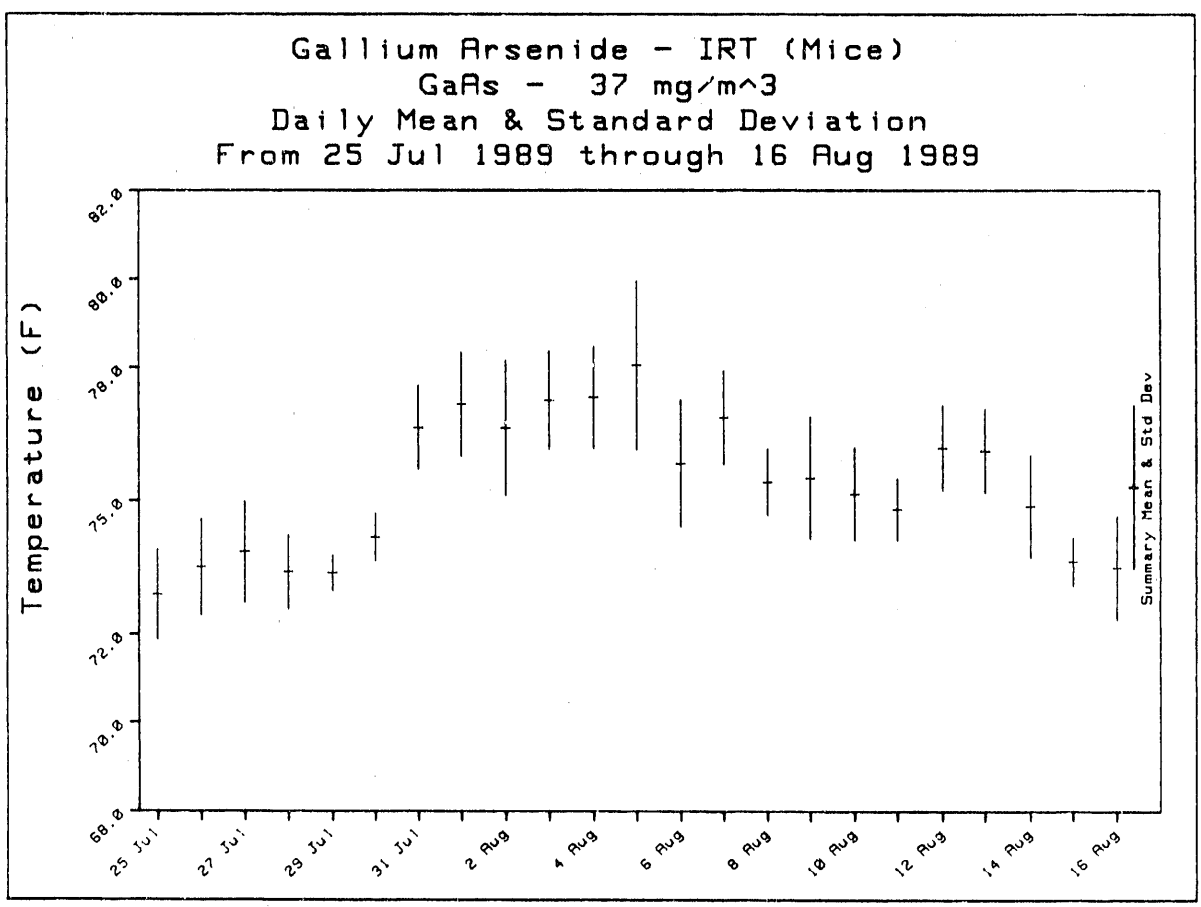
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	73.3	97.7%	.96	1.3%	74.5	72.3	6	6	100.0%
26 Jul 1989	73.5	97.9%	.86	1.2%	74.7	72.3	8	8	100.0%
27 Jul 1989	73.4	97.8%	1.04	1.4%	75.2	72.3	8	8	100.0%
28 Jul 1989	73.1	97.4%	.54	.7%	73.9	72.2	8	8	100.0%
29 Jul 1989	73.2	97.7%	.46	.6%	73.8	72.3	8	8	100.0%
30 Jul 1989	73.4	97.8%	.60	.8%	74.2	72.3	8	8	100.0%
31 Jul 1989	76.0	101.3%	.86	1.1%	76.7	74.0	8	8	100.0%
1 Aug 1989	76.7	102.2%	1.05	1.4%	78.0	75.2	7	6	85.7%
2 Aug 1989	76.3	101.7%	1.07	1.4%	77.7	74.6	8	8	100.0%
3 Aug 1989	76.0	101.4%	1.16	1.5%	77.2	73.7	7	7	100.0%
4 Aug 1989	75.1	100.2%	.41	.5%	75.5	74.5	8	8	100.0%
5 Aug 1989	75.7	101.0%	1.50	2.0%	78.3	74.1	6	5	83.3%
6 Aug 1989	76.4	101.9%	1.33	1.7%	78.1	74.5	7	6	85.7%
7 Aug 1989	77.2	102.9%	1.01	1.3%	78.2	75.6	8	6	75.0%
8 Aug 1989	75.9	101.2%	.72	.9%	76.8	75.0	6	6	100.0%
9 Aug 1989	75.4	100.6%	1.24	1.6%	77.5	73.9	7	7	100.0%
10 Aug 1989	74.9	99.9%	.92	1.2%	76.1	73.4	8	8	100.0%
11 Aug 1989	74.5	99.3%	.70	.9%	75.4	73.7	7	7	100.0%
12 Aug 1989	76.3	101.8%	.63	.8%	77.2	75.8	6	6	100.0%
13 Aug 1989	76.2	101.6%	.79	1.0%	77.1	75.0	7	7	100.0%
14 Aug 1989	75.3	100.4%	1.10	1.5%	77.1	74.0	6	6	100.0%
15 Aug 1989	73.7	98.3%	.45	.6%	74.1	73.1	6	6	100.0%
16 Aug 1989	73.5	98.1%	1.17	1.6%	74.9	71.5	8	7	87.5%
Summary	75.0	99.9%	1.59	2.1%	78.3	71.5	166	160	96.4%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 37 mg/m^3 /Temperature Range= 72.0 to 78.0

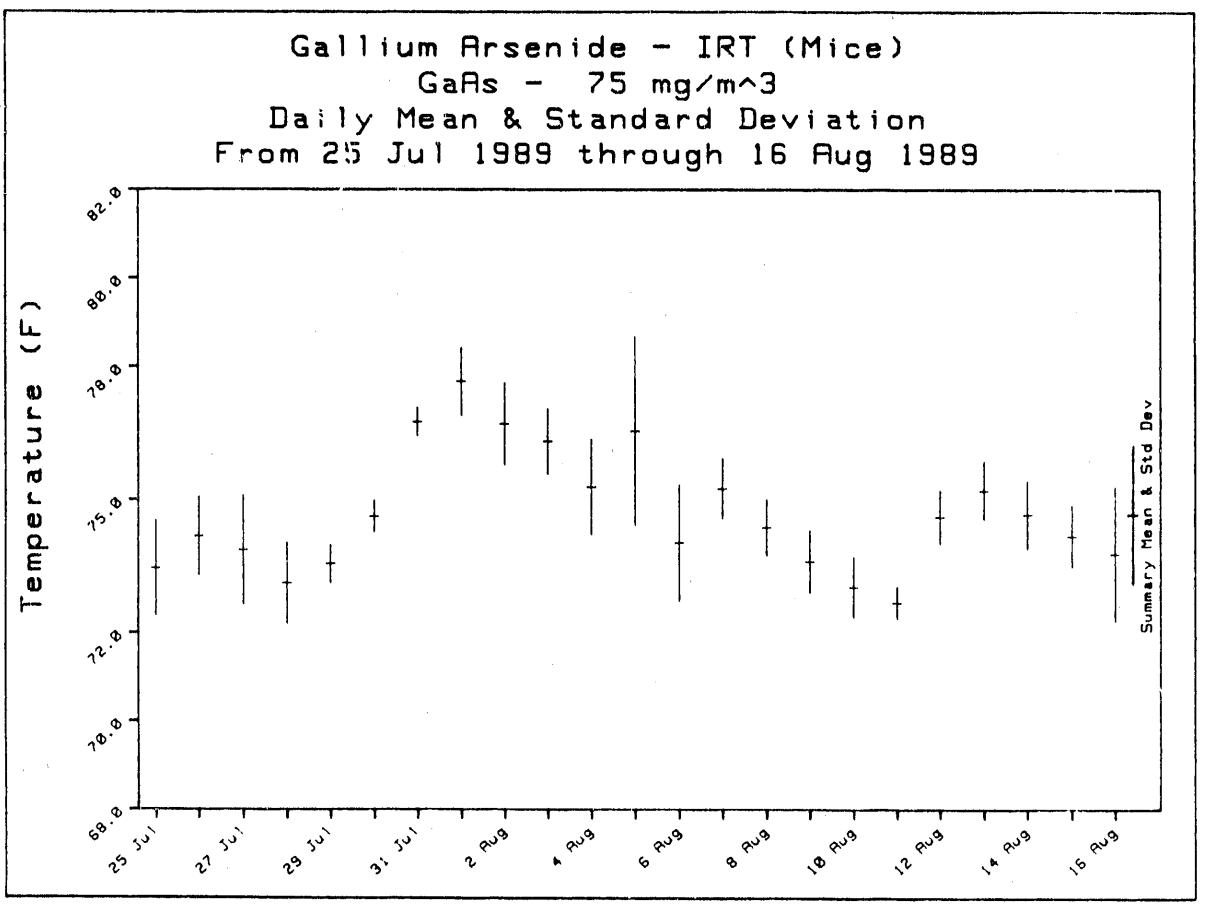
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	72.9	97.2%	1.01	1.4%	74.2	71.7	6	5	83.3%
26 Jul 1989	73.5	98.0%	1.08	1.5%	75.0	71.5	8	7	87.5%
27 Jul 1989	73.8	98.5%	1.14	1.5%	75.6	72.6	8	8	100.0%
28 Jul 1989	73.4	97.9%	.83	1.1%	75.1	72.6	8	8	100.0%
29 Jul 1989	73.4	97.8%	.40	.5%	74.0	72.7	8	8	100.0%
30 Jul 1989	74.2	98.9%	.53	.7%	74.6	73.0	8	8	100.0%
31 Jul 1989	76.7	102.2%	.93	1.2%	77.5	74.5	8	8	100.0%
1 Aug 1989	77.2	102.9%	1.16	1.5%	78.5	75.7	7	4	57.1%
2 Aug 1989	76.6	102.2%	1.52	2.0%	79.1	74.6	8	7	87.5%
3 Aug 1989	77.3	103.0%	1.09	1.4%	78.4	75.8	8	5	62.5%
4 Aug 1989	77.3	103.1%	1.14	1.5%	78.9	76.0	8	5	62.5%
5 Aug 1989	78.1	104.1%	1.89	2.4%	80.0	74.5	6	2	33.3%
6 Aug 1989	75.8	101.1%	1.43	1.9%	77.6	73.7	7	7	100.0%
7 Aug 1989	76.9	102.5%	1.05	1.4%	78.0	75.5	8	7	87.5%
8 Aug 1989	75.4	100.6%	.75	1.0%	76.1	74.3	6	6	100.0%
9 Aug 1989	75.5	100.7%	1.38	1.8%	77.0	73.7	8	8	100.0%
10 Aug 1989	75.2	100.2%	1.05	1.4%	76.7	73.5	8	8	100.0%
11 Aug 1989	74.8	99.7%	.69	.9%	75.9	73.8	7	7	100.0%
12 Aug 1989	76.2	101.6%	.95	1.2%	77.2	74.8	6	6	100.0%
13 Aug 1989	76.1	101.5%	94	1.2%	77.1	74.8	7	7	100.0%
14 Aug 1989	74.9	99.8%	1.16	1.6%	77.1	73.8	6	6	100.0%
15 Aug 1989	73.6	98.2%	.54	.7%	74.2	72.8	6	6	100.0%
16 Aug 1989	73.5	98.0%	1.16	1.6%	74.8	71.4	8	7	87.5%
Summary	75.3	100.4%	1.83	2.4%	80.0	71.4	168	150	89.3%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 75 mg/m^3 /Temperature Range= 72.0 to 78.0

Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	73.5	97.9%	1.08	1.5%	74.8	72.2	6	6	100.0%
26 Jul 1989	74.2	98.9%	.88	1.2%	75.1	72.9	7	7	100.0%
27 Jul 1989	73.9	98.5%	1.23	1.7%	75.8	72.5	8	8	100.0%
28 Jul 1989	73.1	97.5%	.92	1.3%	75.0	72.4	7	7	100.0%
29 Jul 1989	73.6	98.1%	.43	.6%	74.5	73.2	7	7	100.0%
30 Jul 1989	74.6	99.5%	.35	.5%	75.1	74.3	7	7	100.0%
31 Jul 1989	76.8	102.4%	.31	.4%	77.2	76.5	7	7	100.0%
1 Aug 1989	77.7	103.6%	.76	1.0%	78.6	77.0	6	4	66.7%
2 Aug 1989	76.7	102.3%	.91	1.2%	78.6	75.8	8	7	87.5%
3 Aug 1989	76.3	101.8%	.73	1.0%	77.2	75.2	7	7	100.0%
4 Aug 1989	75.3	100.4%	1.06	1.4%	76.3	73.5	8	8	100.0%
5 Aug 1989	76.6	102.1%	2.11	2.8%	78.7	73.2	5	4	80.0%
6 Aug 1989	74.1	98.7%	1.31	1.8%	75.6	71.9	7	6	85.7%
7 Aug 1989	75.3	100.4%	.67	.9%	76.1	74.5	8	8	100.0%
8 Aug 1989	74.4	99.2%	.62	.8%	75.4	73.4	7	7	100.0%
9 Aug 1989	73.6	98.2%	.70	1.0%	74.5	72.7	7	7	100.0%
10 Aug 1989	73.1	97.4%	.68	.9%	73.7	72.0	7	7	100.0%
11 Aug 1989	72.7	96.9%	.36	.5%	73.3	72.3	6	6	100.0%
12 Aug 1989	74.6	99.5%	.60	.8%	75.4	73.7	6	6	100.0%
13 Aug 1989	75.2	100.3%	.64	.9%	76.3	74.3	7	7	100.0%
14 Aug 1989	74.7	99.6%	.76	1.0%	76.1	73.9	6	6	100.0%
15 Aug 1989	74.2	98.9%	.69	.9%	74.8	73.2	6	6	100.0%
16 Aug 1989	73.8	98.4%	1.52	2.1%	75.6	71.7	7	6	85.7%
Summary	74.7	99.6%	1.55	2.1%	78.7	71.7	157	151	96.2%

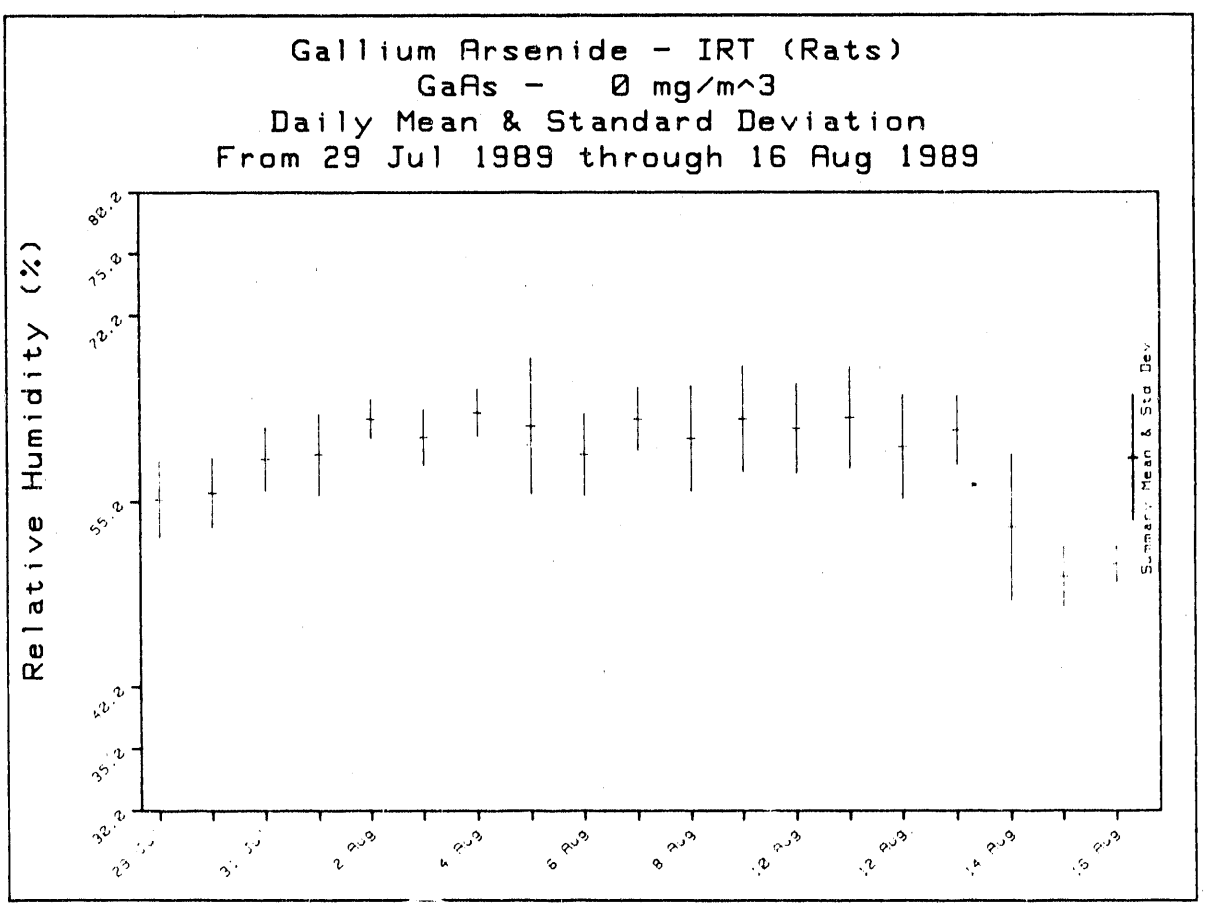


Relative Humidity Data

Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 0 mg/m^3 /Relative Humidity Range= 40.0 to 70.0

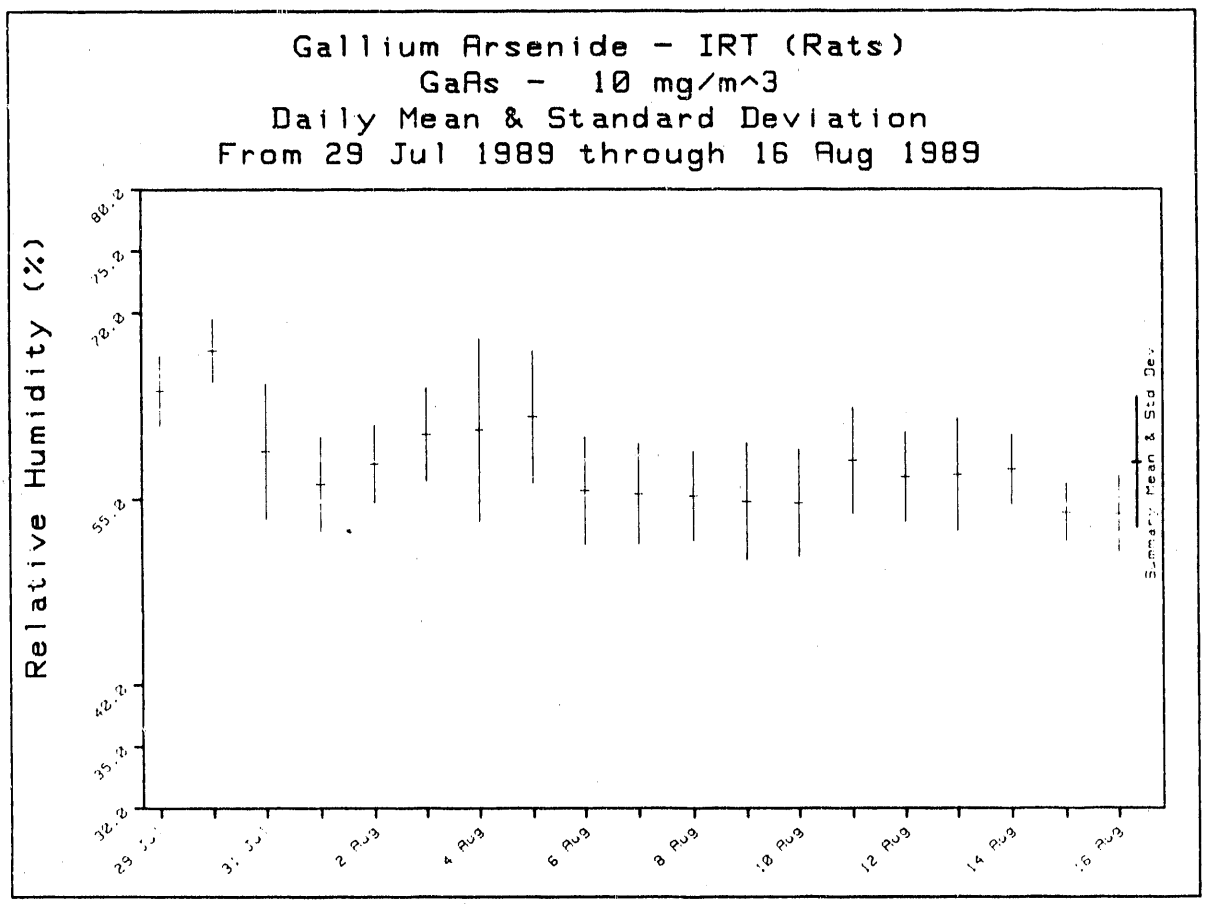
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	55.2	100.5%	3.11	5.6%	60.0	50.0	8	8	100.0%
30 Jul 1989	55.7	101.4%	2.82	5.1%	59.0	51.0	8	8	100.0%
31 Jul 1989	58.5	106.4%	2.56	4.4%	64.0	56.0	8	8	100.0%
1 Aug 1989	58.9	107.0%	3.29	5.6%	63.0	54.0	7	7	100.0%
2 Aug 1989	61.8	112.3%	1.58	2.6%	64.0	59.0	8	8	100.0%
3 Aug 1989	60.3	109.5%	2.25	3.7%	63.0	57.0	8	8	100.0%
4 Aug 1989	62.3	113.2%	1.91	3.1%	64.0	59.0	8	8	100.0%
5 Aug 1989	61.2	111.2%	5.49	9.0%	69.0	53.0	6	6	100.0%
6 Aug 1989	58.9	107.0%	3.29	5.6%	62.0	53.0	7	7	100.0%
7 Aug 1989	61.8	112.3%	2.55	4.1%	65.0	58.0	8	8	100.0%
8 Aug 1989	60.2	109.4%	4.26	7.1%	66.0	55.0	6	6	100.0%
9 Aug 1989	61.8	112.3%	4.27	6.9%	69.0	57.0	8	8	100.0%
10 Aug 1989	61.0	110.9%	3.63	5.9%	66.0	56.0	8	8	100.0%
11 Aug 1989	61.9	112.5%	4.10	6.6%	66.0	57.0	7	7	100.0%
12 Aug 1989	59.5	108.2%	4.18	7.0%	64.0	53.0	6	6	100.0%
13 Aug 1989	60.9	110.6%	2.79	4.6%	64.0	56.0	7	7	100.0%
14 Aug 1989	53.0	96.4%	5.92	11.2%	66.0	48.0	7	7	100.0%
15 Aug 1989	49.0	89.1%	2.45	5.0%	52.0	45.0	6	6	100.0%
16 Aug 1989	50.0	90.9%	1.51	3.0%	53.0	49.0	8	8	100.0%
Summary	58.6	106.5%	5.02	8.6%	69.0	45.0	139	139	100.0%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 10 mg/m^3 /Relative Humidity Range= 40.0 to 70.0

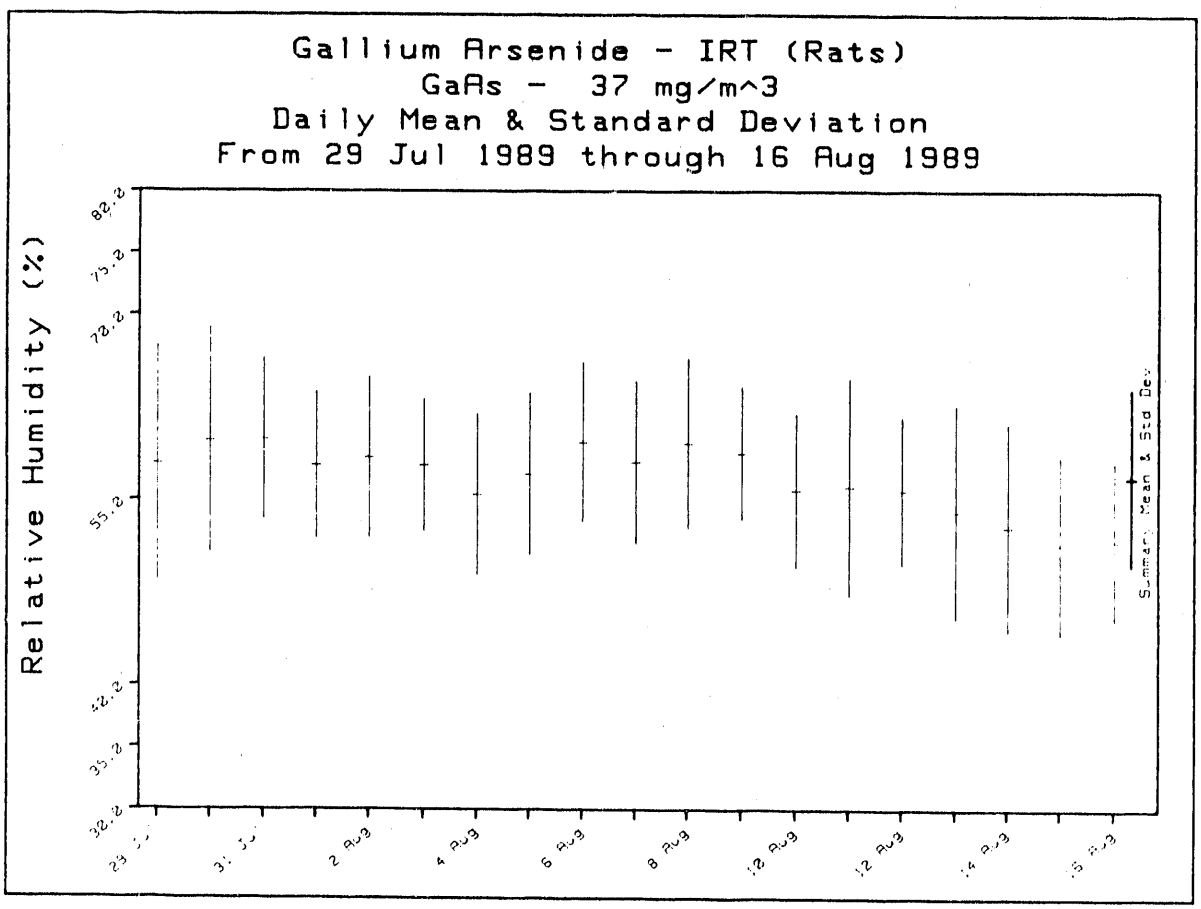
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	63.8	115.9%	2.82	4.4%	67.0	59.0	8	8	100.0%
30 Jul 1989	67.0	121.8%	2.56	3.8%	69.0	61.0	8	8	100.0%
31 Jul 1989	58.9	107.0%	5.41	9.2%	71.0	54.0	8	7	87.5%
1 Aug 1989	56.3	102.3%	3.77	6.7%	61.0	51.0	7	7	100.0%
2 Aug 1989	57.9	105.2%	3.09	5.3%	61.0	53.0	8	8	100.0%
3 Aug 1989	60.3	109.5%	3.73	6.2%	64.0	53.0	8	8	100.0%
4 Aug 1989	60.6	110.2%	7.33	12.1%	69.0	52.0	8	8	100.0%
5 Aug 1989	61.7	112.1%	5.28	8.6%	70.0	55.0	6	6	100.0%
6 Aug 1989	55.7	101.4%	4.30	7.7%	62.0	48.0	8	8	100.0%
7 Aug 1989	55.5	100.9%	4.00	7.2%	60.0	50.0	8	8	100.0%
8 Aug 1989	55.3	100.6%	3.56	6.4%	60.0	51.0	6	6	100.0%
9 Aug 1989	54.9	99.8%	4.67	8.5%	64.0	50.0	8	8	100.0%
10 Aug 1989	54.7	99.5%	4.27	7.8%	60.0	49.0	8	8	100.0%
11 Aug 1989	58.1	105.7%	4.22	7.3%	62.0	51.0	7	7	100.0%
12 Aug 1989	56.8	103.3%	3.54	6.2%	60.0	52.0	6	6	100.0%
13 Aug 1989	57.0	103.6%	4.47	7.8%	62.0	50.0	7	7	100.0%
14 Aug 1989	57.4	104.4%	2.76	4.8%	61.0	53.0	7	7	100.0%
15 Aug 1989	54.0	98.2%	2.31	4.3%	57.0	51.0	7	7	100.0%
16 Aug 1989	53.9	98.0%	3.04	5.7%	59.0	50.0	8	8	100.0%
Summary	57.9	105.3%	5.19	9.0%	71.0	48.0	141	140	99.3%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 37 mg/m^3 /Relative Humidity Range= 40.0 to 70.0

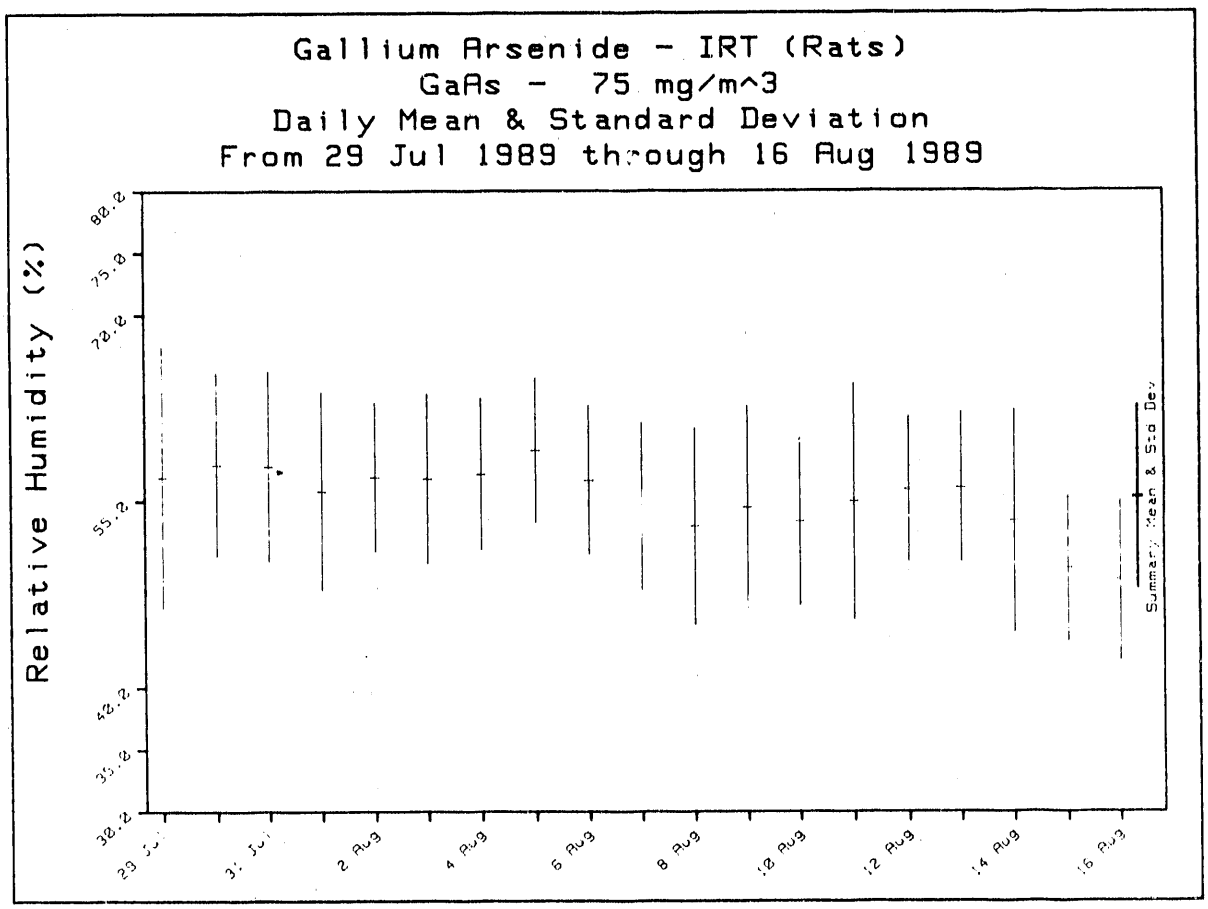
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N In	% N In
29 Jul 1989	58.0	105.5%	9.50	16.4%	66.0	43.0	8	8	100.0%
30 Jul 1989	59.9	108.9%	9.08	15.2%	67.0	44.0	8	8	100.0%
31 Jul 1989	60.0	109.1%	6.50	10.8%	68.0	48.0	8	8	100.0%
1 Aug 1989	57.9	105.2%	5.93	10.2%	64.0	49.0	7	7	100.0%
2 Aug 1989	58.5	106.4%	6.52	11.2%	63.0	47.0	8	8	100.0%
3 Aug 1989	57.9	105.2%	5.36	9.3%	63.0	49.0	8	8	100.0%
4 Aug 1989	55.5	100.9%	6.55	11.8%	61.0	47.0	8	8	100.0%
5 Aug 1989	57.2	103.9%	6.55	11.5%	65.0	47.0	6	6	100.0%
6 Aug 1989	59.8	108.6%	6.48	10.8%	68.0	47.0	8	8	100.0%
7 Aug 1989	58.1	105.7%	6.58	11.3%	64.0	48.0	8	8	100.0%
8 Aug 1989	59.7	108.5%	6.86	11.5%	66.0	50.0	6	6	100.0%
9 Aug 1989	58.9	107.0%	5.36	9.1%	67.0	50.0	8	8	100.0%
10 Aug 1989	55.9	101.6%	6.22	11.1%	62.0	45.0	8	8	100.0%
11 Aug 1989	56.1	102.1%	8.78	15.6%	63.0	43.0	7	7	100.0%
12 Aug 1989	55.8	101.5%	5.98	10.7%	63.0	45.0	6	6	100.0%
13 Aug 1989	54.1	98.4%	8.63	15.9%	61.0	39.0	7	6	85.7%
14 Aug 1989	52.9	96.1%	8.45	16.0%	62.0	39.0	7	6	85.7%
15 Aug 1989	51.4	93.5%	7.21	14.0%	58.0	39.0	7	6	85.7%
16 Aug 1989	51.7	94.1%	6.43	12.4%	60.0	41.0	8	8	100.0%
Summary	56.9	103.4%	7.13	12.5%	68.0	39.0	141	138	97.9%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 75 mg/m^3 /Relative Humidity Range= 40.0 to 70.0

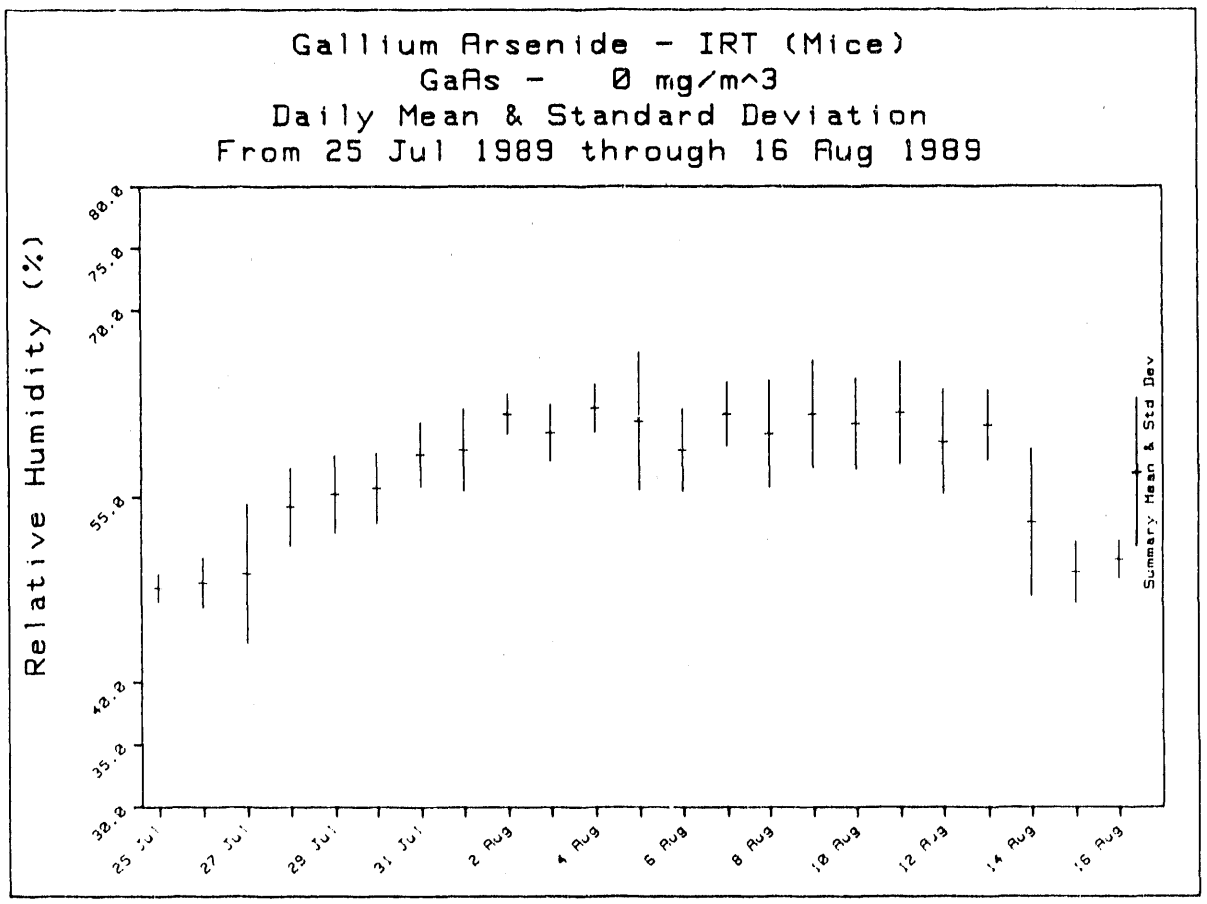
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	57.0	103.6%	10.56	18.5%	65.0	40.0	8	8	100.0%
30 Jul 1989	58.0	105.5%	7.39	12.7%	65.0	44.0	8	8	100.0%
31 Jul 1989	57.9	105.2%	7.66	13.2%	66.0	44.0	8	8	100.0%
1 Aug 1989	55.9	101.6%	7.97	14.3%	63.0	43.0	7	7	100.0%
2 Aug 1989	57.0	103.6%	6.00	10.5%	62.0	47.0	8	8	100.0%
3 Aug 1989	56.9	103.4%	6.83	12.0%	62.0	45.0	8	8	100.0%
4 Aug 1989	57.3	104.1%	6.11	10.7%	64.0	50.0	8	8	100.0%
5 Aug 1989	59.2	107.6%	5.81	9.8%	64.0	49.0	6	6	100.0%
6 Aug 1989	56.8	103.2%	6.02	10.6%	62.0	45.0	8	8	100.0%
7 Aug 1989	54.6	99.3%	6.74	12.3%	62.0	44.0	8	8	100.0%
8 Aug 1989	53.0	96.4%	7.95	15.0%	60.0	42.0	6	6	100.0%
9 Aug 1989	54.5	99.1%	8.19	15.0%	66.0	42.0	8	8	100.0%
10 Aug 1989	53.4	97.0%	6.76	12.7%	61.0	43.0	8	8	100.0%
11 Aug 1989	55.0	100.0%	9.54	17.3%	64.0	41.0	7	7	100.0%
12 Aug 1989	56.0	101.8%	5.87	10.5%	61.0	45.0	6	6	100.0%
13 Aug 1989	56.1	102.1%	6.07	10.8%	61.0	44.0	7	7	100.0%
14 Aug 1989	53.4	97.1%	8.98	16.8%	63.0	41.0	7	7	100.0%
15 Aug 1989	49.6	90.1%	5.86	11.8%	55.0	39.0	7	6	85.7%
16 Aug 1989	48.6	88.4%	6.41	13.2%	55.0	38.0	8	6	75.0%
Summary	55.3	100.5%	7.35	13.3%	66.0	38.0	141	138	97.9%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 0 mg/m^3 /Relative Humidity Range= 40.0 to 70.0

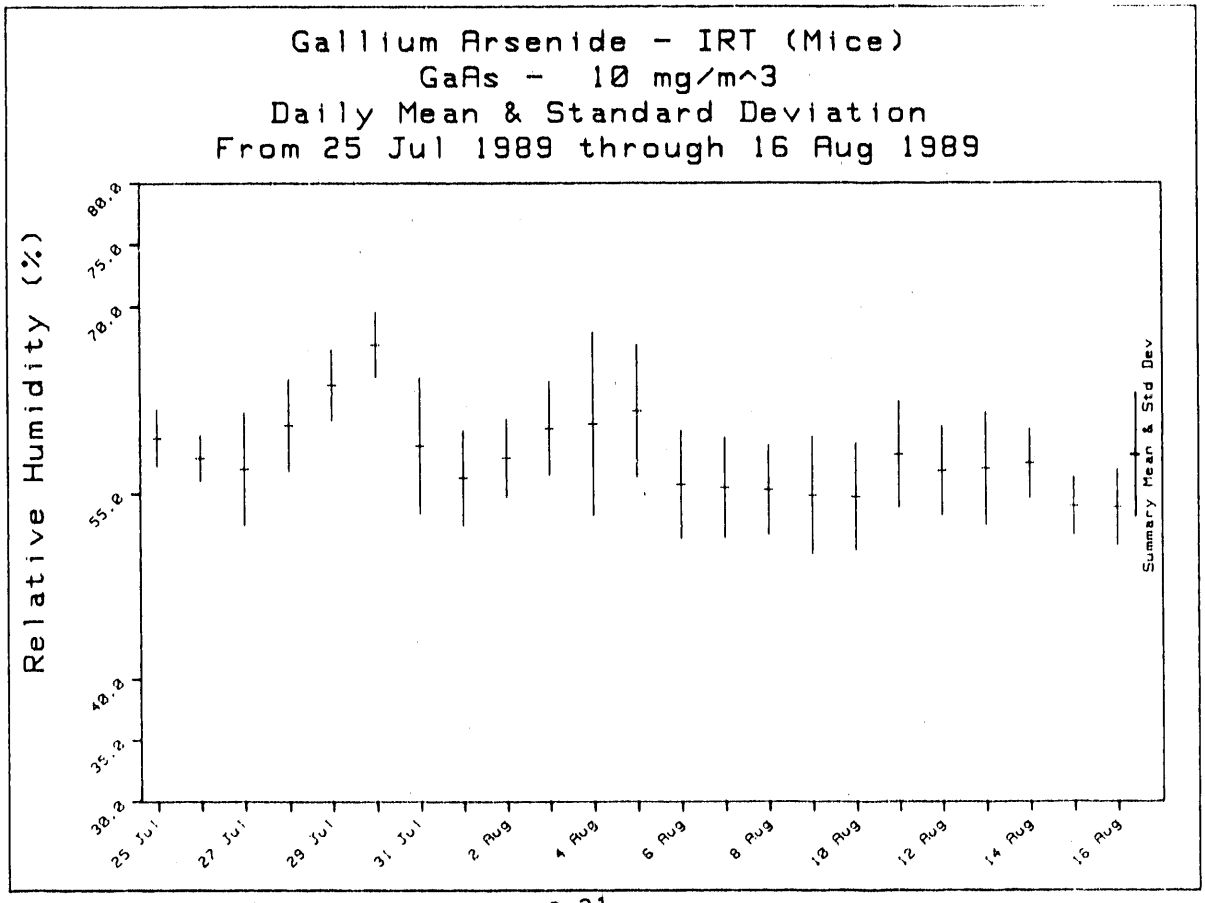
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	47.7	86.8%	1.11	2.3%	49.0	46.0	7	7	100.0%
26 Jul 1989	48.1	87.5%	2.03	4.2%	51.0	46.0	8	8	100.0%
27 Jul 1989	48.9	88.8%	5.61	11.5%	54.0	42.0	7	7	100.0%
28 Jul 1989	54.2	98.6%	3.11	5.7%	57.0	49.0	8	8	100.0%
29 Jul 1989	55.2	100.5%	3.11	5.6%	60.0	50.0	8	8	100.0%
30 Jul 1989	55.7	101.4%	2.82	5.1%	59.0	51.0	8	8	100.0%
31 Jul 1989	58.5	106.4%	2.56	4.4%	64.0	56.0	8	8	100.0%
1 Aug 1989	58.9	107.0%	3.29	5.6%	63.0	54.0	7	7	100.0%
2 Aug 1989	61.8	112.3%	1.58	2.6%	64.0	59.0	8	8	100.0%
3 Aug 1989	60.3	109.5%	2.25	3.7%	63.0	57.0	8	8	100.0%
4 Aug 1989	62.3	113.2%	1.91	3.1%	64.0	59.0	8	8	100.0%
5 Aug 1989	61.2	111.2%	5.49	9.0%	69.0	53.0	6	6	100.0%
6 Aug 1989	58.9	107.0%	3.29	5.6%	62.0	53.0	7	7	100.0%
7 Aug 1989	61.8	112.3%	2.55	4.1%	65.0	58.0	8	8	100.0%
8 Aug 1989	60.2	109.4%	4.26	7.1%	66.0	55.0	6	6	100.0%
9 Aug 1989	61.8	112.3%	4.27	6.9%	69.0	57.0	8	8	100.0%
10 Aug 1989	61.0	110.9%	3.63	5.9%	66.0	56.0	8	8	100.0%
11 Aug 1989	61.9	112.5%	4.10	6.6%	66.0	57.0	7	7	100.0%
12 Aug 1989	59.5	108.2%	4.18	7.0%	64.0	53.0	6	6	100.0%
13 Aug 1989	60.9	110.6%	2.79	4.6%	64.0	56.0	7	7	100.0%
14 Aug 1989	53.0	96.4%	5.92	11.2%	66.0	48.0	7	7	100.0%
15 Aug 1989	49.0	89.1%	2.45	5.0%	52.0	45.0	6	6	100.0%
16 Aug 1989	50.0	90.9%	1.51	3.0%	53.0	49.0	8	8	100.0%
Summary	57.0	103.6%	5.91	10.4%	69.0	42.0	169	169	100.0%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 10 mg/m^3 /Relative Humidity Range= 40.0 to 70.0

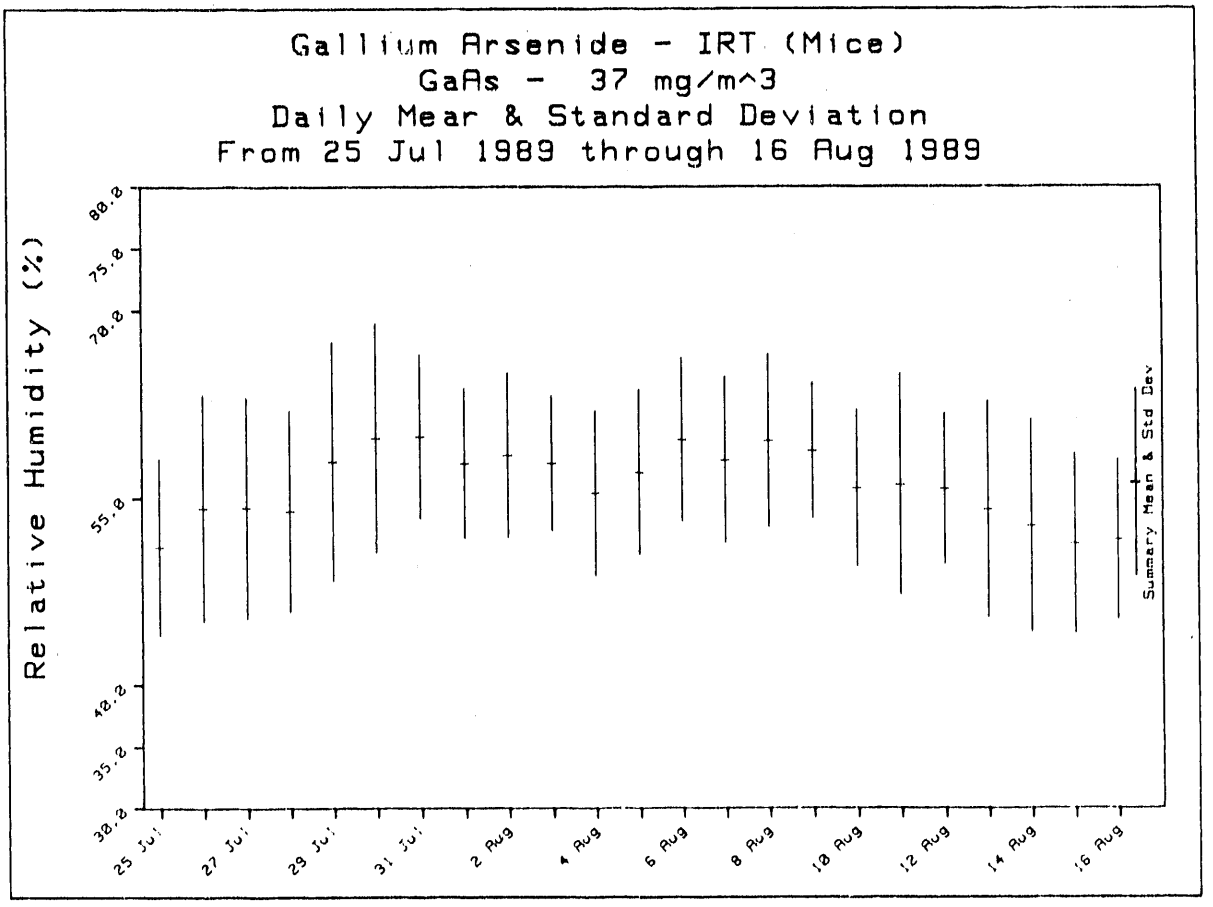
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	59.5	108.2%	2.26	3.8%	63.0	57.0	6	6	100.0%
26 Jul 1989	57.9	105.2%	1.81	3.1%	60.0	55.0	8	8	100.0%
27 Jul 1989	57.0	103.6%	4.47	7.8%	61.0	51.0	7	7	100.0%
28 Jul 1989	60.5	110.0%	3.66	6.1%	65.0	55.0	8	8	100.0%
29 Jul 1989	63.8	115.[illegible]%	2.82	4.4%	67.0	59.0	8	8	100.0%
30 Jul 1989	67.0	121.8%	2.56	3.8%	69.0	61.0	8	8	100.0%
31 Jul 1989	58.9	107.0%	5.41	9.2%	71.0	54.0	8	7	87.5%
1 Aug 1989	56.3	102.3%	3.77	6.7%	61.0	51.0	7	7	100.0%
2 Aug 1989	57.9	105.2%	3.09	5.3%	61.0	53.0	8	8	100.0%
3 Aug 1989	60.3	109.5%	3.73	6.2%	64.0	53.0	8	8	100.0%
4 Aug 1989	60.6	110.2%	7.33	12.1%	69.0	52.0	8	8	100.0%
5 Aug 1989	61.7	112.1%	5.28	8.6%	70.0	55.0	6	6	100.0%
6 Aug 1989	55.7	101.4%	4.30	7.7%	62.0	48.0	8	8	100.0%
7 Aug 1989	55.5	100.9%	4.00	7.2%	60.0	50.0	8	8	100.0%
8 Aug 1989	55.3	100.6%	3.56	6.4%	60.0	51.0	6	6	100.0%
9 Aug 1989	54.9	99.8%	4.67	8.5%	64.0	50.0	8	8	100.0%
10 Aug 1989	54.7	99.5%	4.27	7.8%	60.0	49.0	8	8	100.0%
11 Aug 1989	58.1	105.7%	4.22	7.3%	62.0	51.0	7	7	100.0%
12 Aug 1989	56.8	103.3%	3.54	6.2%	60.0	52.0	6	6	100.0%
13 Aug 1989	57.0	103.6%	4.47	7.8%	62.0	50.0	7	7	100.0%
14 Aug 1989	57.4	104.4%	2.76	4.8%	61.0	53.0	7	7	100.0%
15 Aug 1989	54.0	98.2%	2.31	4.3%	57.0	51.0	7	7	100.0%
16 Aug 1989	53.9	98.0%	3.04	5.7%	59.0	50.0	8	8	100.0%
Summary	58.1	105.6%	4.92	8.5%	71.0	48.0	170	169	99.4%



Daily Summation for Gallium Arsenide - IRT (Mice) From 25 Jul 1989 throu 16 Aug 1989

Summary Data for: GaAs - 37 mg/m^3 /Relative Humidity Range= 40.0 to 70.0

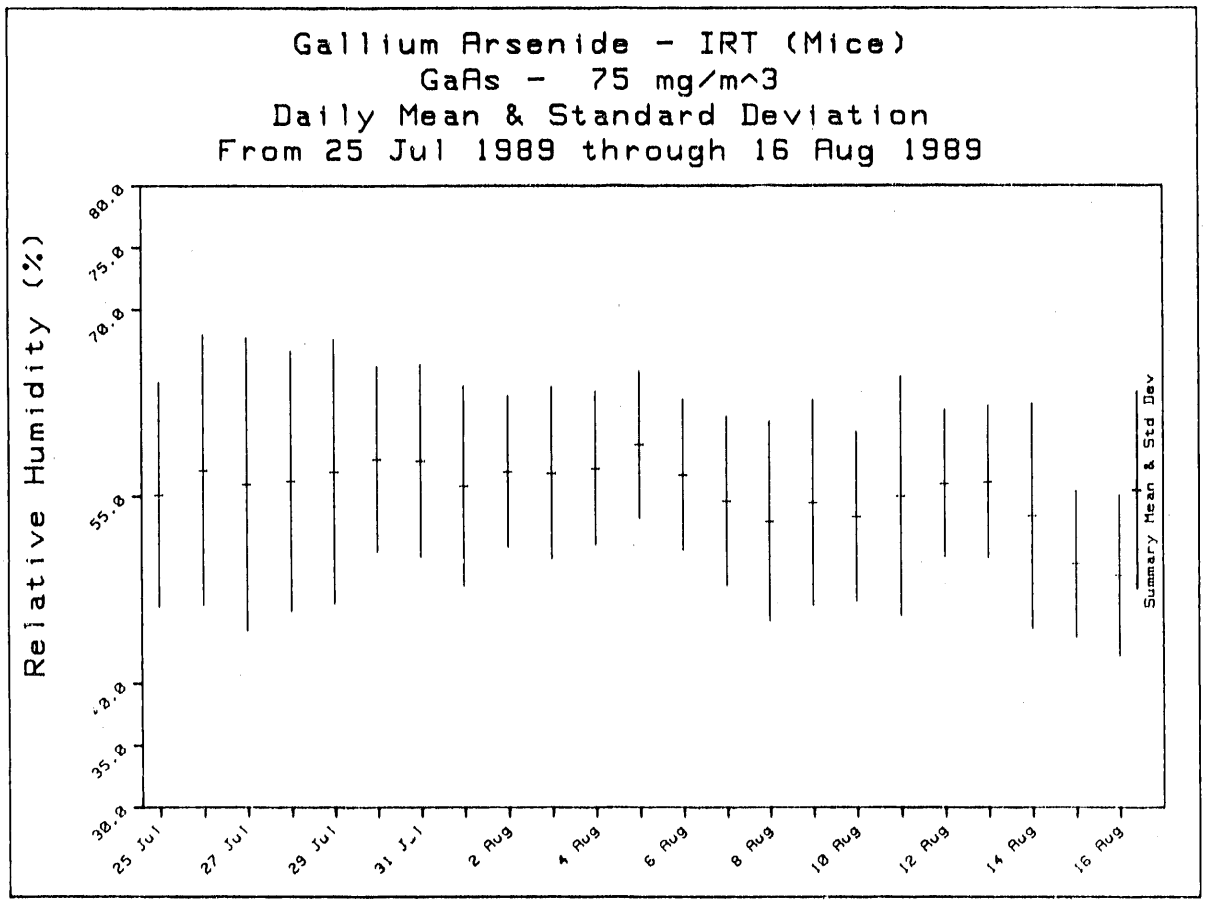
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	51.1	93.0%	7.06	13.8%	58.0	41.0	7	7	100.0%
26 Jul 1989	54.2	98.6%	9.02	16.6%	61.0	39.0	8	7	87.5%
27 Jul 1989	54.3	98.7%	8.81	16.2%	60.0	41.0	7	7	100.0%
28 Jul 1989	54.0	98.2%	8.00	14.8%	60.0	39.0	8	7	87.5%
29 Jul 1989	58.0	105.5%	9.50	16.4%	66.0	43.0	8	8	100.0%
30 Jul 1989	59.9	108.9%	9.08	15.2%	67.0	44.0	8	8	100.0%
31 Jul 1989	60.0	109.1%	6.50	10.8%	68.0	48.0	8	8	100.0%
1 Aug 1989	57.9	105.2%	5.93	10.2%	64.0	49.0	7	7	100.0%
2 Aug 1989	58.5	106.4%	6.52	11.2%	63.0	47.0	8	8	100.0%
3 Aug 1989	57.9	105.2%	5.36	9.3%	63.0	49.0	8	8	100.0%
4 Aug 1989	55.5	100.9%	6.55	11.8%	61.0	47.0	8	8	100.0%
5 Aug 1989	57.2	103.9%	6.55	11.5%	65.0	47.0	6	6	100.0%
6 Aug 1989	59.8	108.6%	6.48	10.8%	68.0	47.0	8	8	100.0%
7 Aug 1989	58.1	105.7%	6.58	11.3%	64.0	48.0	8	8	100.0%
8 Aug 1989	59.7	108.5%	6.86	11.5%	66.0	50.0	6	6	100.0%
9 Aug 1989	58.9	107.0%	5.36	9.1%	67.0	50.0	8	8	100.0%
10 Aug 1989	55.9	101.6%	6.22	11.1%	62.0	45.0	8	8	100.0%
11 Aug 1989	56.1	102.1%	8.78	15.6%	63.0	43.0	7	7	100.0%
12 Aug 1989	55.8	101.5%	5.98	10.7%	63.0	45.0	6	6	100.0%
13 Aug 1989	54.1	98.4%	8.63	15.9%	61.0	39.0	7	6	85.7%
14 Aug 1989	52.9	96.1%	8.45	16.0%	62.0	39.0	7	6	85.7%
15 Aug 1989	51.4	93.5%	7.21	14.0%	58.0	39.0	7	6	85.7%
16 Aug 1989	51.7	94.1%	6.43	12.4%	60.0	41.0	8	8	100.0%
Summary	56.3	102.3%	7.37	13.1%	68.0	39.0	171	166	97.1%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 75 mg/m^3 /Relative Humidity Range= 40.0 to 70.0

Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	55.1	100.3%	8.97	16.3%	65.0	42.0	7	7	100.0%
26 Jul 1989	57.1	103.9%	10.82	18.9%	65.0	38.0	8	7	87.5%
27 Jul 1989	56.0	101.8%	11.72	20.9%	66.0	39.0	7	5	71.4%
28 Jul 1989	56.3	102.3%	10.36	18.4%	68.0	40.0	8	8	100.0%
29 Jul 1989	57.0	103.6%	10.56	18.5%	65.0	40.0	8	8	100.0%
30 Jul 1989	58.0	105.5%	7.39	12.7%	65.0	44.0	8	8	100.0%
31 Jul 1989	57.9	105.2%	7.66	13.2%	66.0	44.0	8	8	100.0%
1 Aug 1989	55.9	101.6%	7.97	14.3%	63.0	43.0	7	7	100.0%
2 Aug 1989	57.0	103.6%	6.00	10.5%	62.0	47.0	8	8	100.0%
3 Aug 1989	56.9	103.4%	6.83	12.0%	62.0	45.0	8	8	100.0%
4 Aug 1989	57.3	104.1%	6.11	10.7%	64.0	50.0	8	8	100.0%
5 Aug 1989	59.2	107.6%	5.81	9.8%	64.0	49.0	6	6	100.0%
6 Aug 1989	56.8	103.2%	6.02	10.6%	62.0	45.0	8	8	100.0%
7 Aug 1989	54.6	99.3%	6.74	12.3%	62.0	44.0	8	8	100.0%
8 Aug 1989	53.0	96.4%	7.95	15.0%	60.0	42.0	6	6	100.0%
9 Aug 1989	54.5	99.1%	8.19	15.0%	66.0	42.0	8	8	100.0%
10 Aug 1989	53.4	97.0%	6.76	12.7%	61.0	43.0	8	8	100.0%
11 Aug 1989	55.0	100.0%	9.54	17.3%	64.0	41.0	7	7	100.0%
12 Aug 1989	56.0	101.8%	5.87	10.5%	61.0	45.0	6	6	100.0%
13 Aug 1989	56.1	102.1%	6.07	10.8%	61.0	44.0	7	7	100.0%
14 Aug 1989	53.4	97.1%	8.98	16.8%	63.0	41.0	7	7	100.0%
15 Aug 1989	49.6	90.1%	5.86	11.8%	55.0	39.0	7	6	85.7%
16 Aug 1989	48.6	88.4%	6.41	13.2%	55.0	38.0	8	6	75.0%
Summary	55.4	100.8%	7.85	14.2%	68.0	38.0	171	165	96.5%

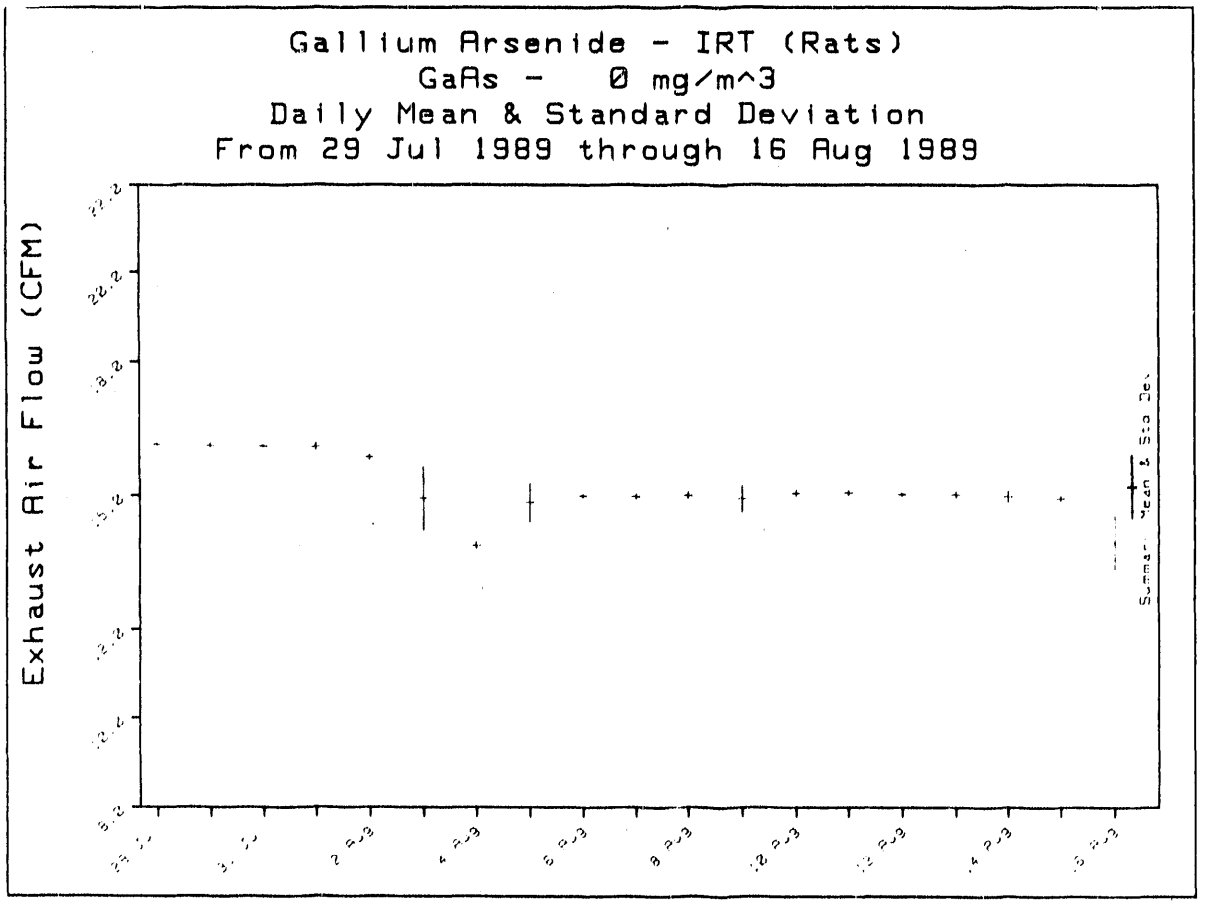


Exhaust Airflow Data

Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 0 mg/m^3 /Exhaust Air Flow Range= 12.0 to 18.0

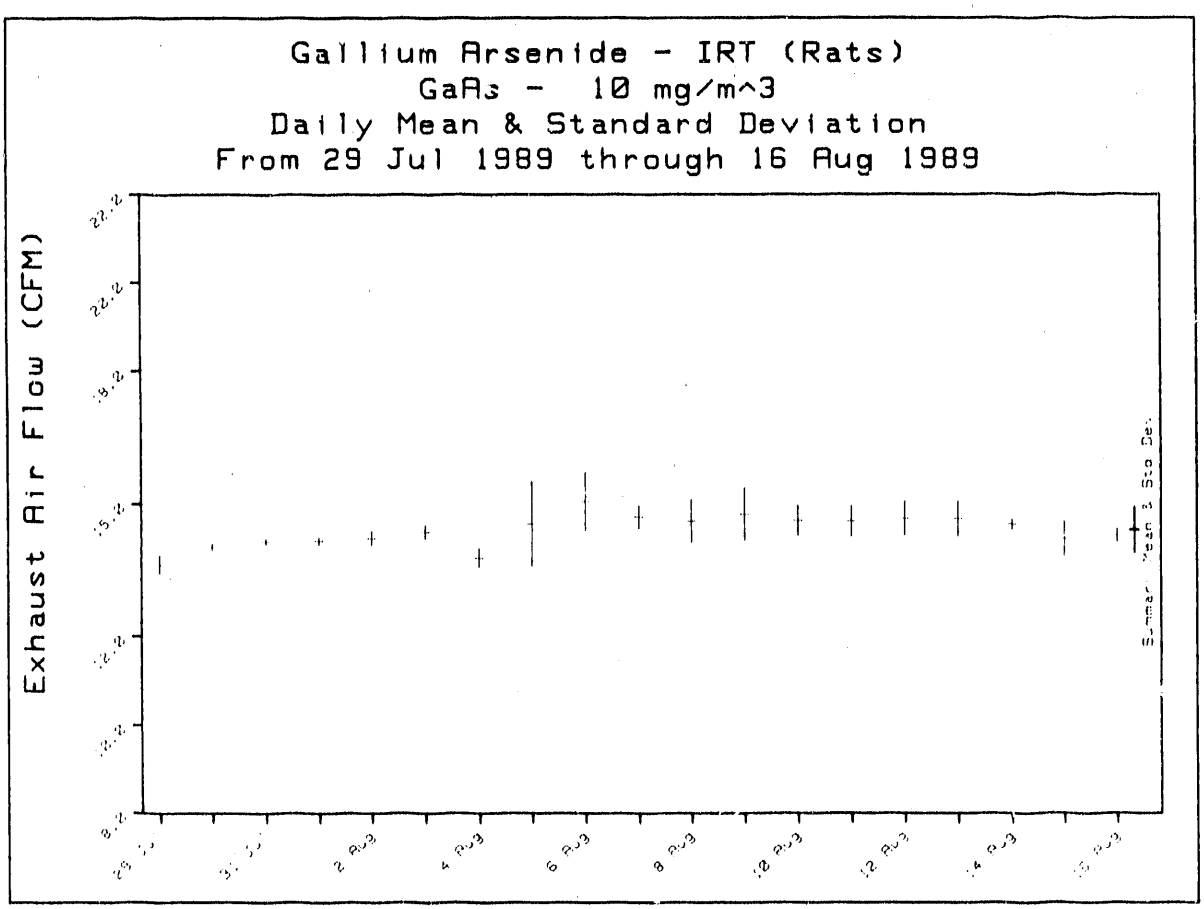
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	16.2	107.8%	.02	.1%	16.2	16.1	9	9	100.0%
30 Jul 1989	16.1	107.7%	.04	.3%	16.2	16.1	9	9	100.0%
31 Jul 1989	16.1	107.5%	.04	.2%	16.2	16.1	8	8	100.0%
1 Aug 1989	16.1	107.4%	.08	.5%	16.2	15.9	9	9	100.0%
2 Aug 1989	15.9	105.9%	.06	.4%	16.0	15.8	9	9	100.0%
3 Aug 1989	15.0	99.7%	.71	4.8%	15.9	14.4	9	9	100.0%
4 Aug 1989	13.9	92.7%	.07	.5%	14.0	13.8	7	7	100.0%
5 Aug 1989	14.9	99.1%	.44	2.9%	15.1	13.9	7	7	100.0%
6 Aug 1989	15.0	100.1%	.04	.3%	15.1	15.0	8	8	100.0%
7 Aug 1989	15.0	100.0%	.06	.4%	15.1	14.9	8	8	100.0%
8 Aug 1989	15.0	100.1%	.08	.5%	15.1	14.9	8	8	100.0%
9 Aug 1989	14.9	99.6%	.30	2.0%	15.2	14.2	8	8	100.0%
10 Aug 1989	15.1	100.5%	.08	.5%	15.2	15.0	8	8	100.0%
11 Aug 1989	15.1	100.6%	.07	.5%	15.2	15.0	9	9	100.0%
12 Aug 1989	15.0	100.3%	.04	.3%	15.1	15.0	6	6	100.0%
13 Aug 1989	15.0	100.3%	.08	.5%	15.2	15.0	8	8	100.0%
14 Aug 1989	15.0	100.0%	.13	.8%	15.2	14.9	7	7	100.0%
15 Aug 1989	14.9	99.6%	.06	.4%	15.1	14.9	7	7	100.0%
16 Aug 1989	14.0	93.1%	.60	4.3%	15.0	13.6	8	8	100.0%
Summary	15.2	101.4%	.69	4.5%	16.2	13.6	152	152	100.0%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 10 mg/m^3 /Exhaust Air Flow Range= 12.0 to 18.0

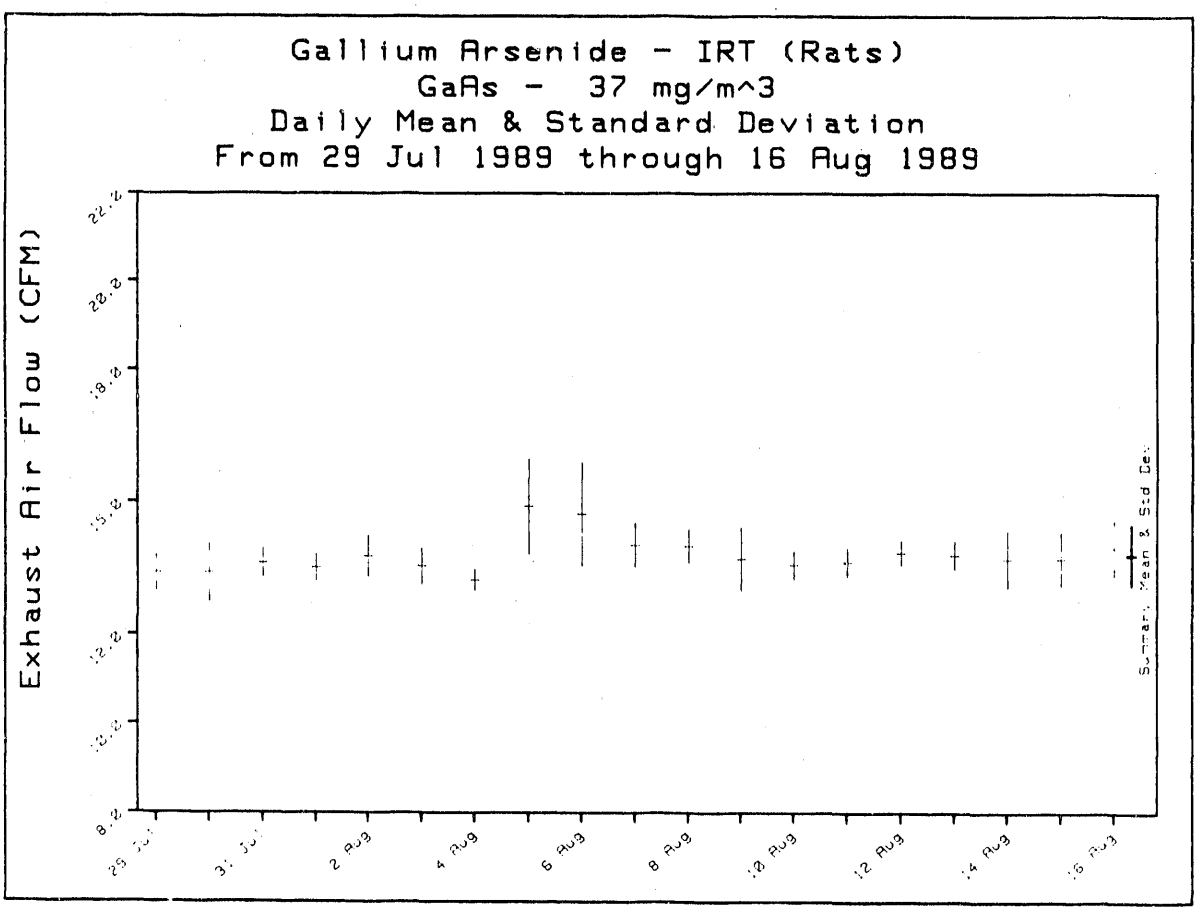
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	13.6	90.9%	.22	1.6%	13.8	13.4	9	9	100.0%
30 Jul 1989	14.0	93.6%	.09	.6%	14.2	13.9	9	9	100.0%
31 Jul 1989	14.2	94.4%	.07	.5%	14.3	14.1	8	8	100.0%
1 Aug 1989	14.2	94.5%	.08	.6%	14.3	14.0	9	9	100.0%
2 Aug 1989	14.2	94.9%	.16	1.1%	14.4	14.0	9	9	100.0%
3 Aug 1989	14.4	95.9%	.16	1.1%	14.5	14.1	9	9	100.0%
4 Aug 1989	13.8	91.9%	.22	1.6%	14.1	13.6	7	7	100.0%
5 Aug 1989	14.6	97.1%	.96	6.6%	16.0	13.5	7	7	100.0%
6 Aug 1989	15.1	100.5%	.65	4.3%	16.0	13.8	8	8	100.0%
7 Aug 1989	14.7	98.2%	.27	1.8%	15.3	14.5	8	8	100.0%
8 Aug 1989	14.6	97.5%	.49	3.4%	15.1	13.9	8	8	100.0%
9 Aug 1989	14.8	98.6%	.60	4.1%	15.7	13.6	9	9	100.0%
10 Aug 1989	14.6	97.6%	.34	2.4%	15.0	14.1	8	8	100.0%
11 Aug 1989	14.6	97.5%	.35	2.4%	14.8	14.0	9	9	100.0%
12 Aug 1989	14.7	97.9%	.39	2.6%	14.9	13.9	6	6	100.0%
13 Aug 1989	14.7	97.9%	.40	2.7%	15.2	14.0	8	8	100.0%
14 Aug 1989	14.6	97.1%	.12	.8%	14.8	14.4	7	7	100.0%
15 Aug 1989	14.2	94.8%	.39	2.8%	14.5	13.5	7	7	100.0%
16 Aug 1989	14.3	95.3%	.16	1.1%	14.5	14.0	8	8	100.0%
Summary	14.4	96.1%	.51	3.5%	16.0	13.4	153	153	100.0%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 37 mg/m^3 /Exhaust Air Flow Range= 12.0 to 18.0

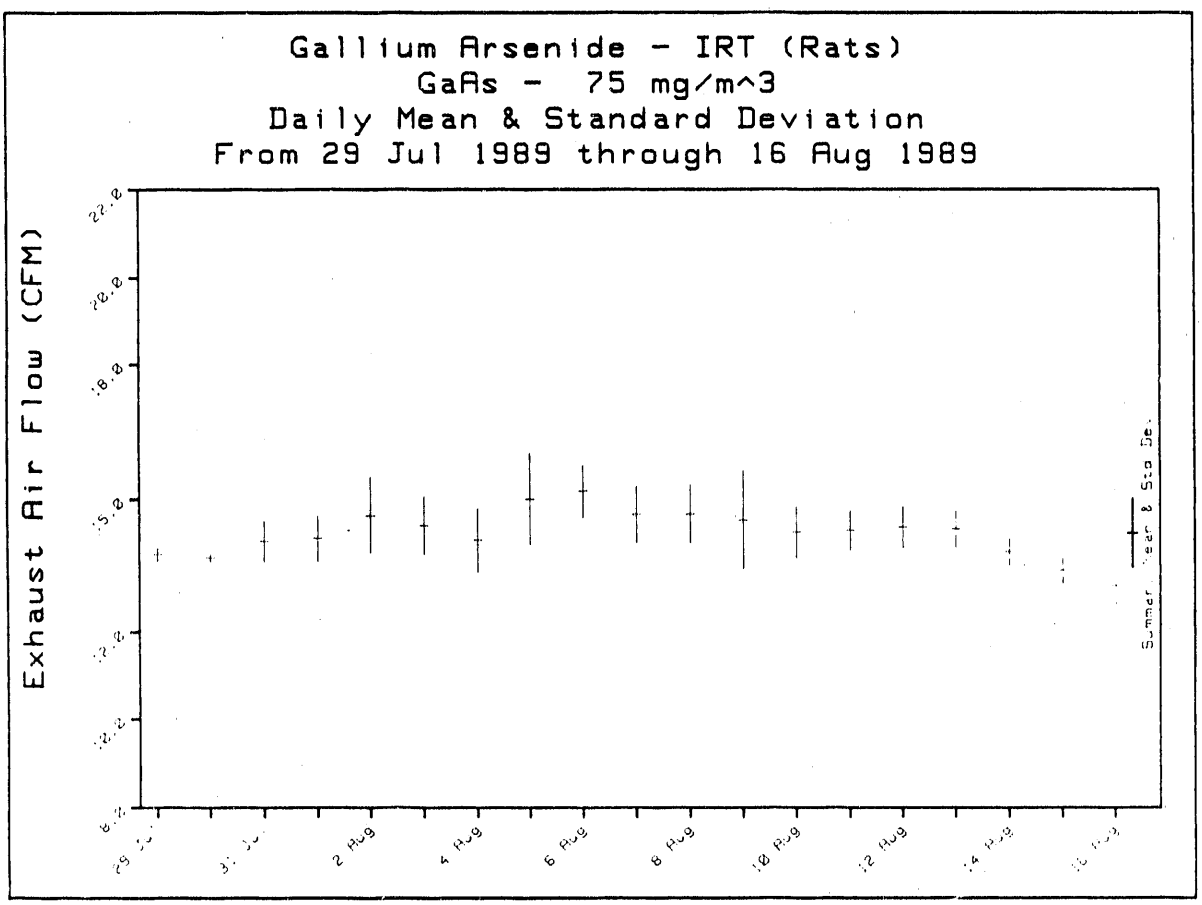
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	13.4	89.3%	.41	3.1%	13.7	12.4	9	9	100.0%
30 Jul 1989	13.4	89.4%	.65	4.9%	14.2	12.3	9	9	100.0%
31 Jul 1989	13.6	90.8%	.32	2.4%	13.9	13.2	8	8	100.0%
1 Aug 1989	13.5	90.1%	.31	2.3%	13.9	12.8	9	9	100.0%
2 Aug 1989	13.8	91.9%	.47	3.4%	14.2	13.1	9	9	100.0%
3 Aug 1989	13.6	90.4%	.41	3.0%	14.2	12.8	9	9	100.0%
4 Aug 1989	13.2	88.3%	.24	1.8%	13.5	12.9	7	7	100.0%
5 Aug 1989	14.9	99.4%	1.08	7.2%	16.3	13.4	8	8	100.0%
6 Aug 1989	14.7	98.2%	1.18	8.0%	16.3	12.8	8	8	100.0%
7 Aug 1989	14.0	93.6%	.49	3.5%	15.1	13.5	8	8	100.0%
8 Aug 1989	14.0	93.4%	.38	2.7%	14.4	13.3	8	8	100.0%
9 Aug 1989	13.7	91.5%	.70	5.1%	15.4	12.9	9	9	100.0%
10 Aug 1989	13.6	90.6%	.32	2.3%	13.9	13.0	8	8	100.0%
11 Aug 1989	13.6	91.0%	.32	2.4%	13.9	13.0	9	9	100.0%
12 Aug 1989	13.9	92.4%	.27	1.9%	14.0	13.3	6	6	100.0%
13 Aug 1989	13.8	92.1%	.32	2.3%	14.2	13.5	8	8	100.0%
14 Aug 1989	13.7	91.4%	.64	4.7%	14.2	12.9	7	7	100.0%
15 Aug 1989	13.7	91.5%	.60	4.4%	14.1	12.6	7	7	100.0%
16 Aug 1989	14.0	93.1%	.63	4.5%	14.5	12.9	8	8	100.0%
Summary	13.8	92.0%	.67	4.9%	16.3	12.3	154	154	100.0%



Daily Summation For Gallium Arsenide - IRT (Rats) From 29 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 75 mg/m^3 /Exhaust Air Flow Range= 12.0 to 18.0

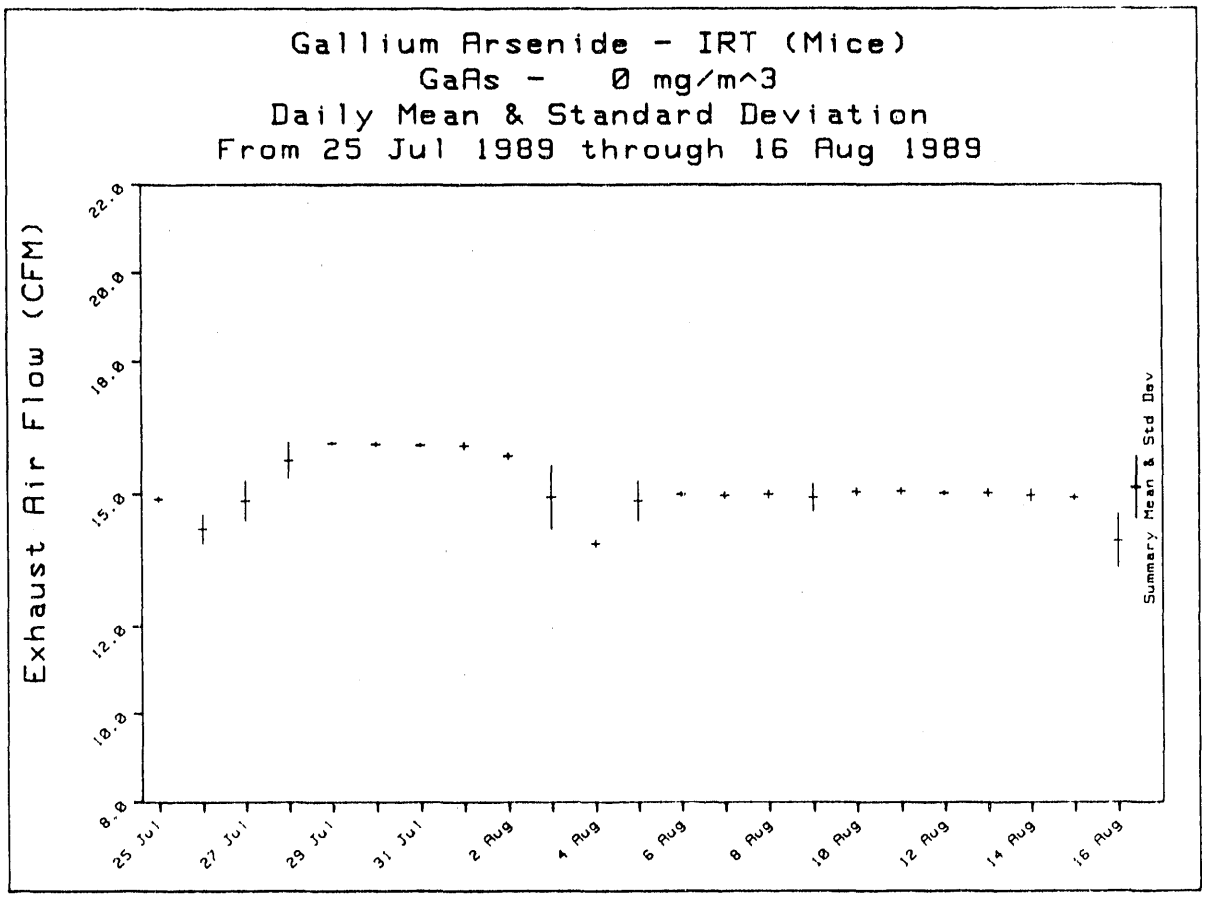
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
29 Jul 1989	13.8	91.7%	.15	1.1%	14.1	13.6	9	9	100.0%
30 Jul 1989	13.7	91.2%	.08	.6%	13.8	13.6	9	9	100.0%
31 Jul 1989	14.1	93.7%	.46	3.3%	14.5	13.5	8	8	100.0%
1 Aug 1989	14.1	94.1%	.51	3.6%	14.8	13.2	9	9	100.0%
2 Aug 1989	14.6	97.7%	.85	5.8%	15.4	13.3	9	9	100.0%
3 Aug 1989	14.4	96.1%	.65	4.5%	15.4	13.2	9	9	100.0%
4 Aug 1989	14.1	93.9%	.72	5.1%	14.7	13.2	7	7	100.0%
5 Aug 1989	15.0	100.1%	1.02	6.8%	16.5	13.4	8	8	100.0%
6 Aug 1989	15.2	101.3%	.58	3.8%	16.5	14.5	8	8	100.0%
7 Aug 1989	14.7	97.8%	.64	4.3%	15.3	13.6	8	8	100.0%
8 Aug 1989	14.7	97.8%	.65	4.4%	15.2	13.6	8	8	100.0%
9 Aug 1989	14.5	96.9%	1.10	7.6%	17.0	13.3	9	9	100.0%
10 Aug 1989	14.3	95.1%	.58	4.0%	14.7	13.2	8	8	100.0%
11 Aug 1989	14.3	95.4%	.45	3.1%	14.6	13.3	9	9	100.0%
12 Aug 1989	14.4	95.9%	.47	3.3%	14.6	13.4	6	6	100.0%
13 Aug 1989	14.3	95.6%	.42	2.9%	14.9	13.6	8	8	100.0%
14 Aug 1989	13.8	92.1%	.31	2.2%	14.5	13.5	7	7	100.0%
15 Aug 1989	13.4	89.3%	.28	2.1%	13.9	13.2	7	7	100.0%
16 Aug 1989	13.0	87.0%	.43	3.3%	13.8	12.7	8	8	100.0%
Summary	14.2	94.9%	.77	5.4%	17.0	12.7	154	154	100.0%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 0 mg/m^3 /Exhaust Air Flow Range= 12.0 to 18.0

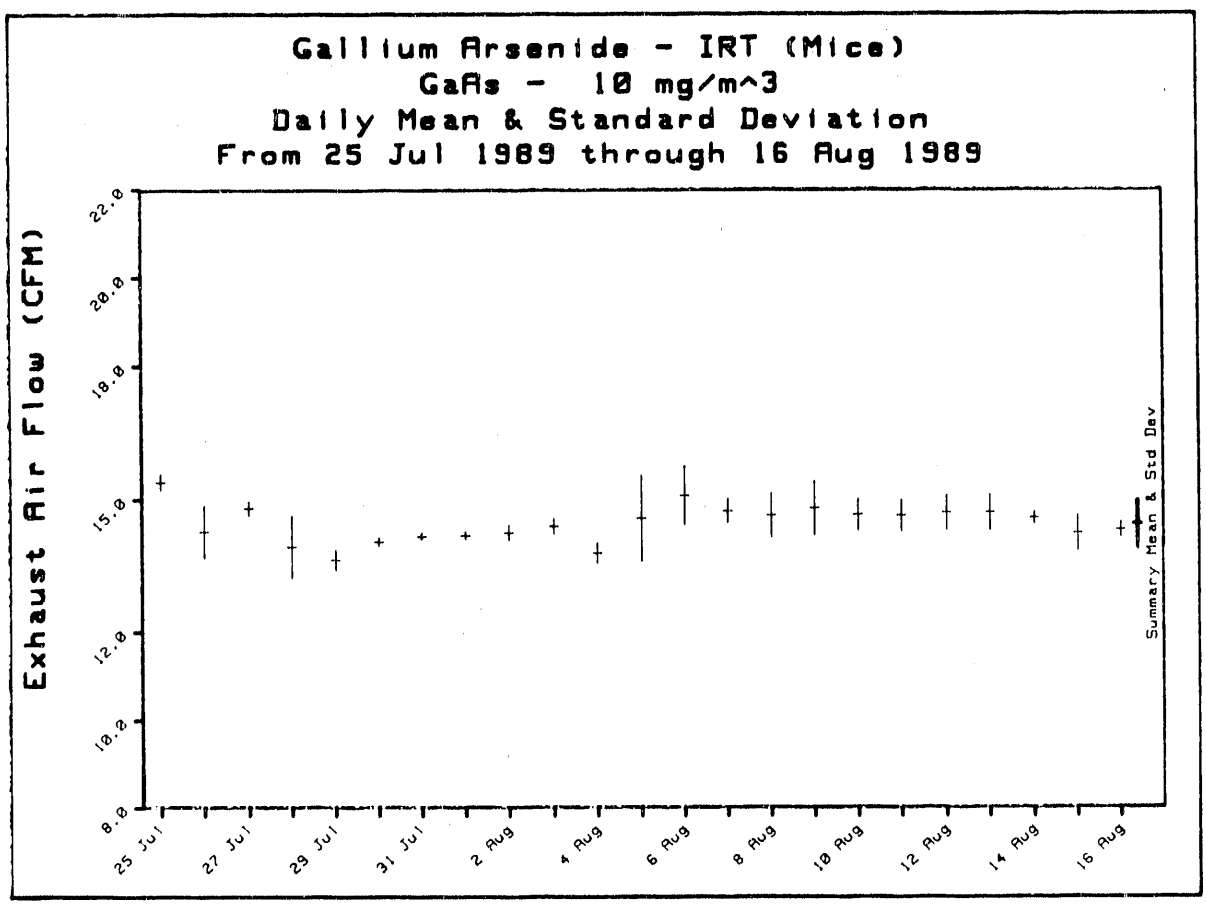
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	14.9	99.4%	.05	.4%	15.0	14.9	6	6	100.0%
26 Jul 1989	14.2	94.9%	.33	2.3%	14.9	14.0	8	8	100.0%
27 Jul 1989	14.9	99.1%	.44	3.0%	15.4	14.5	8	8	100.0%
28 Jul 1989	15.8	105.2%	.40	2.5%	16.2	15.4	8	8	100.0%
29 Jul 1989	16.2	107.8%	.02	.1%	16.2	16.1	9	9	100.0%
30 Jul 1989	16.1	107.7%	.04	.3%	16.2	16.1	9	9	100.0%
31 Jul 1989	16.1	107.5%	.04	.2%	16.2	16.1	8	8	100.0%
1 Aug 1989	16.1	107.4%	.08	.5%	16.2	15.9	9	9	100.0%
2 Aug 1989	15.9	105.9%	.06	.4%	16.0	15.8	9	9	100.0%
3 Aug 1989	15.0	99.7%	.71	4.8%	15.9	14.4	9	9	100.0%
4 Aug 1989	13.9	92.7%	.07	.5%	14.0	13.8	7	7	100.0%
5 Aug 1989	14.9	99.1%	.44	2.9%	15.1	13.9	7	7	100.0%
6 Aug 1989	15.0	100.1%	.04	.3%	15.1	15.0	8	8	100.0%
7 Aug 1989	15.0	100.0%	.06	.4%	15.1	14.9	8	8	100.0%
8 Aug 1989	15.0	100.1%	.08	.5%	15.1	14.9	8	8	100.0%
9 Aug 1989	14.9	99.6%	.30	2.0%	15.2	14.2	8	8	100.0%
10 Aug 1989	15.1	100.5%	.08	.5%	15.2	15.0	8	8	100.0%
11 Aug 1989	15.1	100.6%	.07	.5%	15.2	15.0	9	9	100.0%
12 Aug 1989	15.0	100.3%	.04	.3%	15.1	15.0	6	6	100.0%
13 Aug 1989	15.0	100.3%	.08	.5%	15.2	15.0	8	8	100.0%
14 Aug 1989	15.0	100.0%	.13	.8%	15.2	14.9	7	7	100.0%
15 Aug 1989	14.9	99.6%	.06	.4%	15.1	14.9	7	7	100.0%
16 Aug 1989	14.0	93.1%	.60	4.3%	15.0	13.6	8	8	100.0%
Summary	15.2	101.1%	.69	4.6%	16.2	13.6	182	182	100.0%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 10 mg/m^3 /Exhaust Air Flow Range= 12.0 to 18.0

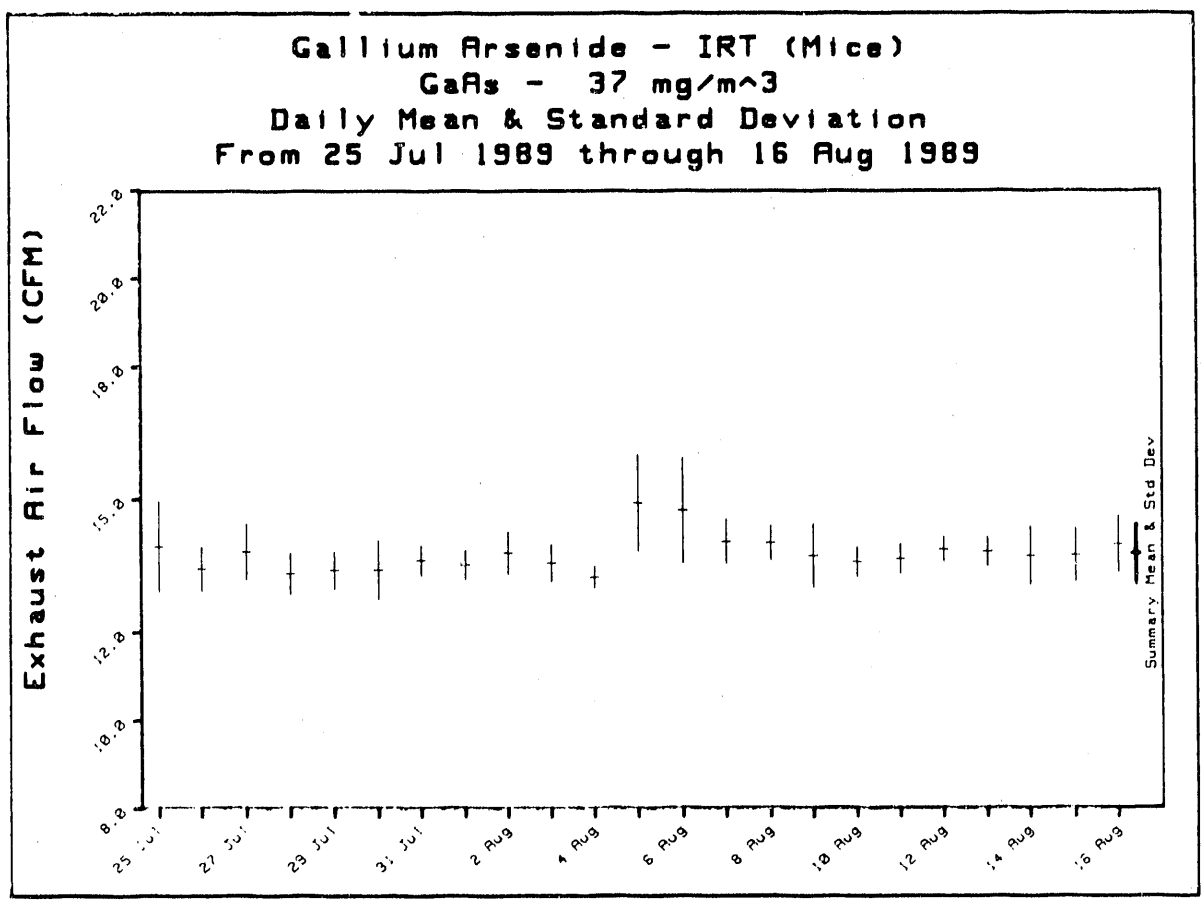
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	15.4	102.5%	.17	1.1%	15.7	15.3	6	6	100.0%
26 Jul 1989	14.3	95.1%	.58	4.0%	15.3	13.8	8	8	100.0%
27 Jul 1989	14.8	98.6%	.15	1.0%	15.0	14.5	8	8	100.0%
28 Jul 1989	13.9	92.8%	.70	5.0%	14.9	13.3	8	8	100.0%
29 Jul 1989	13.6	90.9%	.22	1.6%	13.8	13.4	9	9	100.0%
30 Jul 1989	14.0	93.6%	.09	.6%	14.2	13.9	9	9	100.0%
31 Jul 1989	14.2	94.4%	.07	.5%	14.3	14.1	8	8	100.0%
1 Aug 1989	14.2	94.5%	.08	.6%	14.3	14.0	9	9	100.0%
2 Aug 1989	14.2	94.9%	.16	1.1%	14.4	14.0	9	9	100.0%
3 Aug 1989	14.4	95.9%	.16	1.1%	14.5	14.1	9	9	100.0%
4 Aug 1989	13.8	91.9%	.22	1.6%	14.1	13.6	7	7	100.0%
5 Aug 1989	14.6	97.1%	.96	6.6%	16.0	13.5	7	7	100.0%
6 Aug 1989	15.1	100.5%	.65	4.3%	16.0	13.8	8	8	100.0%
7 Aug 1989	14.7	98.2%	.27	1.8%	15.3	14.5	8	8	100.0%
8 Aug 1989	14.6	97.5%	.49	3.4%	15.1	13.9	8	8	100.0%
9 Aug 1989	14.8	98.6%	.60	4.1%	15.7	13.6	9	9	100.0%
10 Aug 1989	14.6	97.6%	.34	2.4%	15.0	14.1	8	8	100.0%
11 Aug 1989	14.6	97.5%	.35	2.4%	14.8	14.0	9	9	100.0%
12 Aug 1989	14.7	97.9%	.39	2.6%	14.9	13.9	6	6	100.0%
13 Aug 1989	14.7	97.9%	.40	2.7%	15.2	14.0	8	8	100.0%
14 Aug 1989	14.6	97.1%	.12	.8%	14.8	14.4	7	7	100.0%
15 Aug 1989	14.2	94.8%	.39	2.8%	14.5	13.5	7	7	100.0%
16 Aug 1989	14.3	95.3%	.16	1.1%	14.5	14.0	8	8	100.0%
Summary	14.4	96.2%	.54	3.8%	16.0	13.3	183	183	100.0%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 37 mg/m^3 /Exhaust Air Flow Range= 12.0 to 18.0

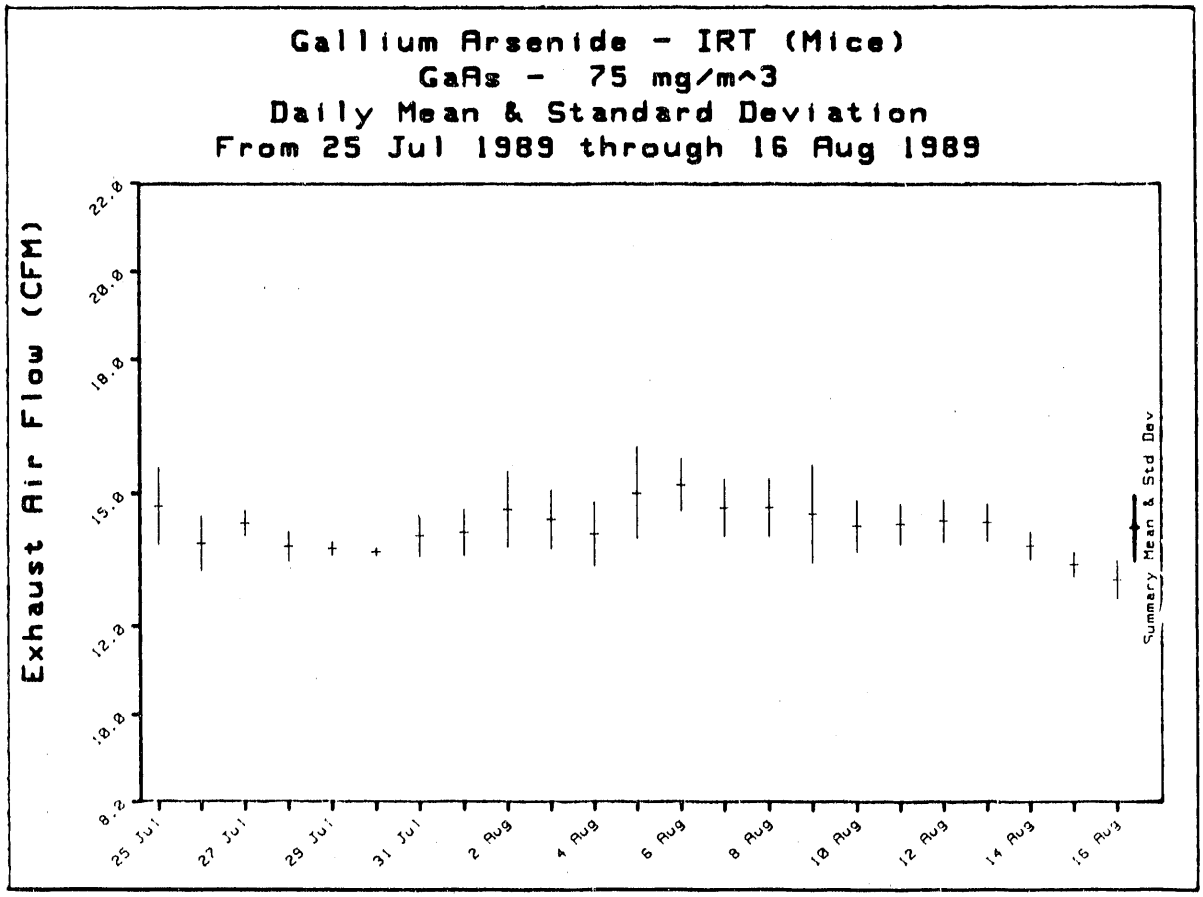
Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	13.9	92.9%	1.00	7.2%	14.6	12.3	6	6	100.0%
26 Jul 1989	13.4	89.5%	.49	3.7%	14.6	12.8	8	8	100.0%
27 Jul 1989	13.8	92.1%	.62	4.5%	14.4	13.0	8	8	100.0%
28 Jul 1989	13.3	88.8%	.46	3.4%	14.4	13.0	8	8	100.0%
29 Jul 1989	13.4	89.3%	.41	3.1%	13.7	12.4	9	9	100.0%
30 Jul 1989	13.4	89.4%	.65	4.9%	14.2	12.3	9	9	100.0%
31 Jul 1989	13.6	90.8%	.32	2.4%	13.9	13.2	8	8	100.0%
1 Aug 1989	13.5	90.1%	.31	2.3%	13.9	12.8	9	9	100.0%
2 Aug 1989	13.8	91.9%	.47	3.4%	14.2	13.1	9	9	100.0%
3 Aug 1989	13.6	90.4%	.41	3.0%	14.2	12.8	9	9	100.0%
4 Aug 1989	13.2	88.3%	.24	1.8%	13.5	12.9	7	7	100.0%
5 Aug 1989	14.9	99.4%	1.08	7.2%	16.3	13.4	8	8	100.0%
6 Aug 1989	14.7	98.2%	1.18	8.0%	16.3	12.8	8	8	100.0%
7 Aug 1989	14.0	93.6%	.49	3.5%	15.1	13.5	8	8	100.0%
8 Aug 1989	14.0	93.4%	.38	2.7%	14.4	13.3	8	8	100.0%
9 Aug 1989	13.7	91.5%	.70	5.1%	15.4	12.9	9	9	100.0%
10 Aug 1989	13.6	90.6%	.32	2.3%	13.9	13.0	8	8	100.0%
11 Aug 1989	13.6	91.0%	.32	2.4%	13.9	13.0	9	9	100.0%
12 Aug 1989	13.9	92.4%	.27	1.9%	14.0	13.3	6	6	100.0%
13 Aug 1989	13.8	92.1%	.32	2.3%	14.2	13.5	8	8	100.0%
14 Aug 1989	13.7	91.4%	.64	4.7%	14.2	12.9	7	7	100.0%
15 Aug 1989	13.7	91.5%	.60	4.4%	14.1	12.6	7	7	100.0%
16 Aug 1989	14.0	93.1%	.63	4.5%	14.5	12.9	8	8	100.0%
Summary	13.8	91.8%	.67	4.9%	16.3	12.3	184	184	100.0%



Daily Summation For Gallium Arsenide - IRT (Mice) From 25 Jul 1989 through 16 Aug 1989

Summary Data for: GaAs - 75 mg/m^3 /Exhaust Air Flow Range= 12.0 to 18.0

Date	Mean	% Target	Std Dev	% RSD	Maximum	Minimum	N	N in	% N in
25 Jul 1989	14.7	98.1%	.86	5.8%	15.3	13.3	6	6	100.0%
26 Jul 1989	13.9	92.5%	.60	4.3%	15.2	13.2	8	8	100.0%
27 Jul 1989	14.3	95.5%	.28	1.9%	14.6	13.9	8	8	100.0%
28 Jul 1989	13.8	92.0%	.33	2.4%	14.6	13.6	8	8	100.0%
29 Jul 1989	13.8	91.7%	.15	1.1%	14.1	13.6	9	9	100.0%
30 Jul 1989	13.7	91.2%	.08	.6%	13.8	13.6	9	9	100.0%
31 Jul 1989	14.1	93.7%	.46	3.3%	14.5	13.5	8	8	100.0%
1 Aug 1989	14.1	94.1%	.51	3.6%	14.8	13.2	9	9	100.0%
2 Aug 1989	14.6	97.7%	.85	5.8%	15.4	13.3	9	9	100.0%
3 Aug 1989	14.4	96.1%	.65	4.5%	15.4	13.2	9	9	100.0%
4 Aug 1989	14.1	93.9%	.72	5.1%	14.7	13.2	7	7	100.0%
5 Aug 1989	15.0	100.1%	1.02	6.8%	16.5	13.4	8	8	100.0%
6 Aug 1989	15.2	101.3%	.58	3.8%	16.5	14.5	8	8	100.0%
7 Aug 1989	14.7	97.8%	.64	4.3%	15.3	13.6	8	8	100.0%
8 Aug 1989	14.7	97.8%	.65	4.4%	15.2	13.6	8	8	100.0%
9 Aug 1989	14.5	96.9%	1.10	7.6%	17.0	13.3	9	9	100.0%
10 Aug 1989	14.3	95.1%	.58	4.0%	14.7	13.2	8	8	100.0%
11 Aug 1989	14.3	95.4%	.45	3.1%	14.6	13.3	9	9	100.0%
12 Aug 1989	14.4	95.9%	.47	3.3%	14.6	13.4	6	6	100.0%
13 Aug 1989	14.3	95.6%	.42	2.9%	14.9	13.6	8	8	100.0%
14 Aug 1989	13.8	92.1%	.31	2.2%	14.5	13.5	7	7	100.0%
15 Aug 1989	13.4	89.3%	.28	2.1%	13.9	13.2	7	7	100.0%
16 Aug 1989	13.0	87.0%	.43	3.3%	13.8	12.7	8	8	100.0%
Summary	14.2	94.8%	.75	5.3%	17.0	12.7	184	184	100.0%



Exposure Operation Discussion Sheets

EXPOSURE OPERATION DISCUSSION SHEET

INCLUDES DISCUSSIONS AND/OR EXPLANATIONS OF PROBLEMS AFFECTING ANIMAL ENVIRONMENT AND EXPOSURES. EXPLANATIONS ARE INCLUDED FOR DATA IN WHICH THERE WERE EXCURSIONS OF DAILY MEAN OR STANDARD DEVIATION BEYOND ALLOWABLE OPERATING LIMITS OR EXCURSIONS OF INDIVIDUAL DATUM BEYOND CRITICAL LIMITS.

STUDY: **Gallium Arsenide Developmental Toxicity Study**

REPORTING PERIOD:

NOTE: 24 Hour Data Collection Period extends from ~5:00 a.m. to ~5:00 a.m.

COMPILED BY: B.J. Greenspan BJ Greenspan DATE: 8/18/89

CHAMBER CONCENTRATION

DATE	DISCUSSION OR EXPLANATION
7/25 - 27/89	No concentration excursions.
7/28/89	37 mg/m^3 chamber; 8:11. Critical low limit exceeded. A concentration of 25.9 mg/m^3 was recorded. No action was taken and subsequent readings were within acceptable limits. The %RSD for the day for that chamber was an acceptable 12%.
7/29/89	No concentration excursions. A computer timimg problem resulted in the RAM readings being corrected for the small offset voltage. This procedure was not indicated for these exposures because of the calibration scheme. The effect of this correction is imperceptable in the data and so no changes will be made other than to circumvent the timing problem of simultaneous HP16 prestart chacks and HP85 RAM zero checks.
7/30/89	37 mg/m^3 chamber; 9:26. Critical high limit exceeded. A concentration of 48.2 mg/m^3 was recorded. A maunal measurement at 9:28 indicated that the chamber was once again within normal limits. The %RSD for the exposure day was an acceptable 12% for that chamber.
7/31/89	No concentration excursions.
8/1/89	No concentration excursions.
8/2/89	37 mg/m^3 chamber; 10:27. Critical high limit exceeded. A concentration of 54.5 mg/m^3 was recorded. A reading at 10:28 indicated normal chamber concentration. This transient resulted in a %RSD of 13% for the day for that chamber.
8/3/89	No concentration excursions.
8/4/89	37 mg/m^3 chamber; 12:57. Critical high limit exceeded. A concentration of 52.1 mg/m^3 was recorded. A manual reading taken at 12:05, after the automatic RAM cycle, was witin acceptable limits. The %RSD for the day for the 37 mg/m^3 chamber was an acceptable 13%.

8/5/89	37 mg/m^3 chamber; 12:01. Critical high limit exceeded. A concentration of 133 mg/m^3 was recorded. Subsequent readings were 61.3 at 12:02, 47.1 at 12:03 and 39.6 at 12:03. (Two readings at 12:03, ~30 seconds apart). This rapid decay is probably indicative of a piece of material entrained in the RAM sample line and valve system. Most excursions occurring within the chamber have a longer duration. The mean concentration for that chamber was 117% of target with an RSD of 69%. 10 mg/m^3 chamber; 11:09. Critical high limit exceeded. A concentration of 15.1 mg/m^3 was recorded. Subsequent readings were within acceptable limits.
8/6-8/89	No concentration excursions.
8/9/89	75 mg/m^3 chamber; 13:04. Critical high limit exceeded. A concentration of 105 mg/m^3 was recorded. A manual reading at 13:07 was within acceptable limits. This excursion was likely due to the release of some material from the Air-Vac pump supplying the chamber. The RSD was an acceptable 13% for that chamber.
8/10/89	1.0 mg/m^3 chamber; 13:31. Critical high limit exceeded. A concentration of 1.52 mg/m^3 was recorded. A manual measurement taken at 13:33 indicated normal concentration again. The %RSD for the chamber was 17%.
8/11 - 12/89	No concentration excursions.
8/13/89	75 mg/m^3 chamber; 9:51. Critical high limit exceeded. A concentration of 101 mg/m^3 was recorded. Other exposure chambers exhibited increased concentrations suggesting that the distribution line concentration was elevated. Manual measurements at 9:54 indicated all chambers within normal limits. 37 mg/m^3 chamber; 12:55. Critical high limit exceeded. A concentration of 48.9 mg/m^3 was recorded. Manual readings at 12:58 indicated normal concentration in the chamber. The %RSD values for all chambers were within acceptable limits, with a maximum of 14% for the 75 mg/m^3 chamber.
8/14 - 15/89	No concentration excursions.
8/16/89	37 mg/m^3 chamber; 13:17. Critical high limit exceeded. A concentration of 166 mg/m^3 was recorded. This value likely represented the release of some material from the Air-Vac pump. Manual measurements takne at 13:27 indicated a concentration of 42.5 mg/m^3. It is important to consider, also, the calibration curve for that RAM. A second-order polynomial is used with the 75 mg/m^3 chamber defining the upper portion of the curve. Readings far in excess of 75 mg/m^3 are not as reliable, and in the case of this RAM where the curve is concave up, the concentration is likely an overestimate. Nevertheless, a relatively brief excursion occurred. The %RSD for the day was 81% with an overall mean concentration at 136% of target. NTP should consider utilizing time-weighted averages to deal with the occasional brief excursions which occur in these studies. Control chamber; 12:01. A concentration of 0.024 mg/m^3 was recorded. This is slightly above the MDL of 0.02 mg/m^3 and probably represents a slight drift in the zero offset voltage for the RAM.

TEMPERATURE & RELATIVE HUMIDITY

DATE	DISCUSSION OR EXPLANATION
7/25/89	Room; 17:32. Critical high temperature limit exceeded. A value of 77.4°F was recorded. Chamber temperatures were within acceptable limits. No action taken.
7/26/89	Room; 8:41. Critical high temperature limit exceeded. A value of 77.5°F was recorded. Chamber temperatures were within acceptable limits. Manaul measurements were also made to see if a temperature imbalance could be discerned in the chambers (port 3B). Less than 1°F difference was found. The room alarm limits were increased to 78.5°F for the remainder of the day.
7/27/89	Room; 19:06. Critical high temperature limit exceeded (limit reset to 77°F). A value of 78.2 was recorded. The room temperature was adjusted downward. A manual measurement at 19:30 indicated a temperature of 75.2°F. Manual measurements indicated all chamber temperatures within normal limits.
7/28/89	Room; 14:04. Critical high temperature limit exceeded. A value of 77.0°F was recorded. No action was taken as the chamber temperatures were within acceptable limits.
7/29 - 8/4/89	No Temperature or Relative Humidity excursions.
8/5/89	37 mg/m^3 chamber; 19:51. Critical high temperature limit exceeded. A value of 80°F was recorded. After several hours of manual measurement and attempts to adjust the temperature in the room and in the exposure chambers, it was decided that the location for the measurement of the temerature was inappropriate for the load of animals present. When the study was first brought on-line, there were only 10 animals in the front of some chambers on one level. Measurement of the temperature at Port 2-Back consistently yielded low readings. The RTD was moved to level 3 to be closer to the animals and, therefore, more representative of the temperature that they experienced. However, as more animals came on study, the RTD was not repositioned to Port 2-Back. This should have been done because the readings taken in the vicinity of high animal loading tend to represent radiant heat rather than the actual chamber air temperature. The excursion has not been edited from the data, but the manual readings obtained during the night while investigating the problem have not been included in the summary.
8/6/89	Room; 6:18. Critical low temperature limit exceeded. A value of 65.4°F was recorded. All chamber temperatures were within specifications. The room thermostat was increased by 1°.
8/7 - 16/89	No Temperature or Relative Humidity excursions.

CHAMBER FLOW & VACUUM

DATE	DISCUSSION OR EXPLANATION
	No Chamber Air Flow or Vacuum excursions.

Chamber Uniformity Data

CHAMBER UNIFORMITY DATA SHEET

COMPOUND: Gallium Arsenide (IRT) **EXPOSURE ROOM NUMBER:** 404

TPV MEASUREMENTS

CHAMBER:	75 mg/m^3		37 mg/m^3		10 mg/m^3		1.0 mg/m^3			
DATE:	7/31/89		7/31/89		8/7/89		8/10/89			
SAMPLE PORT	MONITOR READING	% of Mean	MONITOR READING	% of Mean	MONITOR READING	% of Mean	MONITOR READING	% of Mean	MONITOR READING	% of Mean
BACK: 1B	3.294	103.2%	2.142	100.3%	1.404	98.9%	2.998	99.6%		
2B	3.262	102.2%	2.150	100.7%	1.422	100.1%	2.905	96.5%		
3B	3.213	100.6%	2.092	98.0%	1.447	101.9%	2.899	96.3%		
4B	3.247	101.7%	2.141	100.2%	1.426	100.4%	2.963	98.4%		
5B	3.206	100.4%	2.245	105.1%	1.401	98.7%	3.048	101.2%		
6B	3.122	97.8%	2.262	105.9%	1.408	99.2%	3.164	105.1%		
FRONT: 1F	3.143	98.4%	2.011	94.2%	1.432	100.8%	3.073	102.0%		
2F	3.189	99.9%	2.083	97.5%	1.404	98.9%	3.083	102.4%		
3F	3.104	97.2%	2.147	100.5%	1.415	99.6%	3.000	99.6%		
4F	3.299	103.3%	2.180	102.1%	1.433	100.9%	3.010	100.0%		
5F	3.120	97.7%	2.133	99.9%	1.422	100.1%	3.020	100.3%		
6F	3.114	97.5%	2.043	95.7%	1.426	100.4%	2.973	98.7%		
MEAN:	3.193	100.0%	2.136	100.0%	1.420	100.0%	3.011	100.0%		
TPV:	0.072	2.2%	0.073	3.4%	0.014	1.0%	0.075	2.5%		
BPV:	////////////	*	////////////	*	////////////	**0.7%**	////////////	*	////////////	

* ***Indistinguishable from WPV***

WPV MEASUREMENTS

IN-LINE 1st	3.155	98.2%	2.083	100.9%	1.404	99.3%	3.073	103.5%		
2nd	3.189	99.3%	2.139	103.6%	1.415	100.0%	3.023	101.8%		
3rd	3.294	102.5%	1.971	95.5%	1.424	100.7%	2.809	94.6%		
MEAN:	3.213	100.0%	2.064	100.0%	1.414	100.0%	2.968	100.0%		
WPV:	0.072	2.3%	0.086	4.1%	0.010	0.7%	0.140	4.7%		

[Data located in appropriate daily data file]

MONITOR TYPE: RAM-1 RAM #1 SERIAL # : 1010

COMMENTS: RAM #2 SERIAL # : 1331

RAM #3 SERIAL # : 1142

ENTERED BY: D Foltz DATE: 8/15/89 REVIEWED BY: WC Forsythe DATE: 8/16/89

APPENDIX D

ANIMAL DATA

Animal Health Screen Reports

Animal Health Screen Reports

ARS RODENT HEALTH SCREEN REPORT

Investigator: Mast
Study: Ga As - Teratology
Building: LSL II
Room: 530
Date initiated: 7/10/89

Lab no: S-110
Animal/Shipment no: 890063
Date rc'd: 6/20/89
Source: CR RO1
Species/Strain: Rat/CD
Sex: M/F Age: BD 4/25/89

Status: Ten rats (#1-5, males; 6-10, females) received for pre-exposure health screen to include gross necropsy, nasopharyngeal wash for culture, serology and histopathology

Gross Necropsy

3/10*	Spleen	Portions of splenic capsule are thickened and have rough appearance to surface (#1 & 2). Splenic capsule is slightly thickened over small portions of lateral surface in #5, but is not as prominent as in other two rats affected.

*Number affected/number examined

Serology: Rat

0/10 *	Mycoplasma pulmonis
0/10	Sendai virus
0/10	Pneumonia virus of mice
0/10	RCV/SDAV
0/10	KRV/H1

*Number of positive tests/number tested

Nasopharyngeal culture

2/10 *	Beta hemolytic streptococci, Lancefield Group G (#8,9)
0/10	Bordetella bronchiseptica
0/10	Citrobacter freundii
7/10	Coagulase positive staphylococci
0/10	Klebsiella oxytoca
2/10	Klebsiella pneumoniae(#2,10)
0/10	Pasturella sp.
0/10	Pseudomonas aeruginosa
0/10	Streptococcus pneumoniae
0/10	Corynebacterium kutscheri

*Number of positive cultures/number cultured

Culture: Spleen Rat #5
Growth of Proteus mirabilis from the broth culture

Histopathology

2/10 *	Spleen	Subacute to chronic inflammation on splenic capsule. In some areas the inflammation extends into the splenic parenchyma to a maximum depth of 10 cell diameters. (#1,2) No microscopic lesions were seen in the splenic sections submitted from #5.
1/10	Hard.gl.	Moderate inflammation, predominant cell types are lymphocytes and macrophages; is unilateral. (#6)
1/10	Hard.gl.	Occasional focus of necrosis with associated inflammation (#8)

*Number affected/number examined

Correlation/Summary

Special stains have been ordered on the splenic lesions to look for micro organisms. The Proteus isolate is presumed to be a contaminant unless there is correlation with the tissue stain findings. The splenic lesion is of some concern but at this point is not considered significant enough to warrant rejecting the animals for this study.

Inflammation in Harderian gland is seen on occasion in the absence of sialodacryoadenitis virus (SDAV) or any other detected pathogen. Since the SDAV tests are negative, the Harderian gland lesions are considered insignificant.

The bacterial isolates from the nasopharyngeal cultures are opportunistic organisms which are not expected to cause significant infection in the animals for this study.

These rats are approved for use in the Gallium Arsenide Teratology study. Some follow-up on the splenic lesions at the terminal sacrifice is recommended.

Released for Study on 7/18/89.

Released from Quarantine on 7/18/89.

AE Gasnell 7/19/89
Technologist

7/19/89
Veterinarian

Mast
Brown

ARS RODENT HEALTH SCREEN REPORT

Investigator: Mast
Study: Ga As - Teratology
Building: LSL II
Room: 530
Date initiated: 7/10/89

Lab no: S-110 (Addendum)
Animal/Shipment no: 890063
Date rc'd: 6/20/89
Source: CR RO1
Species/Strain: Rat/CD
Sex: M/F Age: BD 4/25/89

Status: Additional histological stains were done on splenic lesions as a follow-up on the pre-exposure health screen

Histopathology

2/10 * Spleen GMS stain: No organisms seen (#1,2)

Correlation/Summary

The etiology of the inflammation in the splenic capsule remains unknown. Unless the inflammation becomes more extensive, it would not be expected to significantly affect the health of an animal or the uterine environment. The rats should be examined for this lesion at the terminal necropsy to determine incidence and to provide confirmation that there was no significant progression of the lesion in affected animals.

8/4/89

Veterinarian

Mast
Brown

ARS RODENT HEALTH SCREEN REPORT

Investigator: Mast
Study: GaAs Teratology
Building: LSL II
Room: 1428
Date initiated: 8/14/89

Lab no: S-145
Animal/Shipment no: 890063
Date rc'd: 6/20/89
Source: CR RO1
Species/Strain: Rat/CD
Sex: F Age: BD 4/25/89

Status: Blood specimen was received on rat #618 (control) at necropsy for serologic testing

Serology: Rat

0/1	*	Mycoplasma pulmonis
0/1		Sendai virus
0/1		Pneumonia virus of mice
0/1		RCV/SDAV
0/1		KRV/H1

*Number of positive tests/number tested

Correlation/Summary

None of the tests were positive.

Ann E. Jarrell 9/11/89
Technologist

Veterinarian 9/11/89

Mast
Brown

ARS RODENT HEALTH SCREEN REPORT

Investigator: Mast
Study: GaAs Teratology
Building: LSL II
Room: 1428
Date initiated: 8/16/89

Lab no: S-150
Animal/Shipment no: 890063
Date rc'd: 6/20/89
Source: CR RO1
Species/Strain: Rat/CD
Sex: F Age: BD 4/25/89

Status: Blood specimens were received on rats #443, 446, and 649 at necropsy for serologic testing

Serology: Rat

0/3	*	Mycoplasma pulmonis
0/3		Sendai virus
0/3		Pneumonia virus of mice
0/3		RCV/SDAV
0/3		KRV/H1

*Number of positive tests/number tested

Correlation/Summary

None of the tests were positive.

Ann E. Gaucci 9/11/89
Technologist

9/14/89
Veterinarian

Mast
Brown

ARS RODENT HEALTH SCREEN REPORT

Investigator: Mast
Study: GaAs Teratology
Building: LSL II
Room: 1428
Date initiated: 8/16/89

Lab no: S-147
Animal/Shipment no: 890063
Date rc'd: 6/20/89
Source: CR RO1
Species/Strain: Rat/CD
Sex: F Age: BD 4/25/89

Status: Spleen from animal # 561 submitted for culture at necropsy

Gross Necropsy

Spleen — Spleen was presented removed from the animal. There is what appears to be thickened omentum or possibly mesentery firmly attached to the splenic capsule over more than 50% of its surface and less firmly to loosely attached to most of the remainder.

Culture results:

Spleen culture

Direct smear: 3+ cellular material
1+ PMN's
No organisms seen

Culture: Growth of a lactobacillus sp. out of the broth only

Correlation/Summary

The lactobacillus is probably a contaminant. Although the appearance of the lesion suggests it might be caused by infection, we have not been able to identify an infectious agent in this animal or in others examined previously which had similar lesions.

AE Jarrell 9/14/89
Technologist

Veterinarian 9/13/89

Mast

ARS RODENT HEALTH SCREEN REPORT

Investigator: Mast
Study: GaAs Teratology
Building: LSL II
Room: 1428
Date initiated: 8/17/89

Lab no: S-151
Animal/Shipment no: 890063
Date rc'd: 6/20/89
Source: CR RO1
Species/Strain: Rat/CD
Sex: F Age: BD 4/25/89

Status: Blood specimens were received on rats #418, 482, 366, 379, 378, and 472 at necropsy for serologic testing. wording error 4/19/90

Serology: Rat

0/6	*	Mycoplasma pulmonis
0/6		Sendai virus
0/6		Pneumonia virus of mice
0/6		RCV/SDAV
0/6		KRV/H1

*Number of positive tests/number tested

Correlation/Summary
None of the tests were positive.

Ann E. Garrell 9/11/89
Technologist

9/6/89
Veterinarian

Mast
Brown

ARS RODENT HEALTH SCREEN REPORT

Investigator: Mast
Study: Ga As - Teratology
Building: LSL II
Room: 530
Date initiated: 7/10/89

Lab no: S-109
Animal/Shipment no: 890064
Date rc'd: 6/20/89
Source: CR RO3
Species/Strain: Mice/CD-1
Sex: M/F Age: BD 5/1/89

Status: Ten mice (#1-~~5~~ 4①, male; #~~5~~ 5①-10, female) for pre-exposure health screen to include gross necropsy, nasopharyngeal wash for culture, serology and histopathology

① Used only 4 males for health screen due to shortage of male mice in shipment 2/5/90 dj

Gross Necropsy

No significant lesions

Nasopharyngeal culture

0/10 *	Beta hemolytic streptococci
0/10	Bordetella bronchiseptica
0/10	Citrobacter freundii
0/10	Coagulase positive staphylococci
0/10	Klebsiella oxytoca
0/10	Klebsiella pneumoniae
0/10	Pasturella sp.
0/10	Pseudomonas aeruginosa
0/10	Streptococcus pneumoniae
0/10	Corynebacterium kutscheri

*Number of positive cultures/number cultured

Serology: Mouse

0/10 *	Mycoplasma pulmonis
0/10	Sendai virus
0/10	Pneumonia virus of mice
0/10	Mouse hepatitis virus
0/10	GD VII virus
0/10	Minute virus of mice

*Number of positive tests/number tested

Histopathology

2/10	Liver	Occasional tiny focus of hepatocellular necrosis with associated inflammation (#7,9)
1/10	Lung	Rare small focus of pneumonitis (#10)

Correlation/Summary

Liver lesions like those described in 2 of the mice examined are often seen in mice at the initial health screen at BNW. The cause of those lesions has not been determined but screening for pathogens has been consistently negative. In these animals, serological tests, including those for mouse hepatitis virus, have been negative. Special stains on liver tissue sections have been ordered to look for micro organisms. This report will follow but findings are expected to be negative.

The lung lesion seen in one mouse is considered an incidental finding and not an indication of significant infection or other disease.

Released for Study on 7/18/89.

Released from Quarantine on 7/18/89.

AE Garrett 7/19/89
Technologist

Veterinarian 7/19/89

Mast
Brown

ARS RODENT HEALTH SCREEN REPORT

Investigator: Mast
Study: Ga As - Teratology
Building: LSL II
Room: 530
Date initiated: 7/10/89

Lab no: S-112
Animal/Shipment no: 890064
Date rc'd: 6/20/89
Source: CR RO3
Species/Strain: Mice/CD-1
Sex: M Age: BD 6/1/89

Status: Three prestudy mice rejected for study because of apparent poor health status were submitted for examination to ARS lab.

Gross Necropsy

#1 Bite wounds are evident; haircoat is rough. Large amount of dry cheesy exudate in the subcutis extending along dorsal midline from between the eyes to base of tail, 1 1/2 cm to 2 cm wide. Overlying skin is necrotic. There appears to be erosion of bone overlying dorsal portion of brain. See culture results.

Spleen is pale, enlarged.

#2 A 3cm diameter, roughly circular area over dorsal pelvis; overlying tissue necrotic, purulent material in subcutis(same as #1), bite wounds evident. See culture results.

Spleen is pale, enlarged.

#3 Similar to #1 & 2, i.e. rough haircoat, bitewounds apparent, enlarged spleen. See culture results. Right preputial gland distended with purulent material.

Culture results:

#1 Subcutis culture: 4+ Group G beta hemolytic streptococcus
3+ coagulase positive staphylococcus
2+ Proteus sp.

#2 Subcutis culture: 4+ Group G beta hemolytic streptococcus
3+ coagulase positive staphylococcus

#3 subcutis culture: 4+ Group G beta hemolytic streptococcus
3+ coagulase positive staphylococcus
2+ Proteus sp.

Correlation/Summary

The lesions seen in these animals apparently originated as bite wounds and were secondarily infected by Group G streptococci and Staph. aureus. This can be avoided by single housing sexually mature male mice.

AEJarrell 7/19/89
Technologist

Veterinarian 7/19/89

Mast
Brown

ARS RODENT HEALTH SCREEN REPORT

Investigator: Mast
Study: Ga As - Teratology
Building: LSL II
Room: 530
Date initiated: 7/10/89

Lab no: S-109 (Addendum)
Animal/Shipment no: 890064
Date ro'd: 6/20/89
Source: CR RO3
Species/Strain: Mice/CD-1
Sex: M/F Age: BD 5/1/89

Status: Additional histological stains were done on lung and liver lesions as a follow-up on the pre-exposure health screen

Histopathology

2/10	Liver	PAS stain: No organisms seen (#7,9) GMS stain: No organisms seen (#7,9)
1/10	Lung	PAS stain: No organisms seen (#10) GMS stain: No organisms seen (#10)

*Number affected/number examined

Correlation/Summary

No pathogens have been associated with the lesions. The lesions are presumably insignificant.

Veterinarian

Mast
Brown

ARS RODENT HEALTH SCREEN REPORT

Investigator: Mast
Study: Ga As Teratology
Building: LSL II
Room: 1428
Date initiated: 8/9/89

Lab no: S-137
Animal/Shipment no: 890064
Date rc'd: 6/20/89
Source: CR RO3
Species/Strain: Mice/CD-1
Sex: F Age: BD 5/1/89

Status: Ten female mice were submitted for serology testing at the terminal sacrifice necropsy

Serology: Mouse

0/10 *	Mycoplasma pulmonis
0/10	Sendai virus
0/10	Pneumonia virus of mice
0/10	Mouse hepatitis virus
0/10	GD VII virus
0/10	Minute virus of mice

*Number of positive tests/number tested

Correlation/Summary

None of the tests for pathogens were positive.

A E Jarnell 9/5/89
Technologist

Veterinarian 9/5/89

Mast
Brown

APPENDIX E

DEVELOPMENTAL TOXICITY DATA

Calendar of Events
Maternal Body and Organ Weights
Virgin Body and Organ Weights
Male Body and Organ Weights
Reproductive Measures and Fetal Data

Calendar of Events

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents:
CALENDAR OF EVENTS OF FEMALE RATS

Received rats (ARS#890063)	6/20/89
Health screen	7/10/89
Tail tattoo females	7/13 to 7/14/89
Released from quarantine	7/18/89
Weighed female rats	7/24/89
0dg (# positive) weighed, randomized, individually caged	(A) 7/25/89 (33) (B) 7/26/89 (48) (B-dist) 7/26/89 (36) (C) 7/27/89 (41)
Moved to exposure room (4dg)	(A) 7/29/89 (B) 7/30/89 (B-dist) 7/30/89 (C) 7/31/89
Exposure (6 hours/day; 7 days/week; 4-19dg)	(A) 7/29 to 8/13/89 (B) 7/30 to 8/14/89 (B-dist) 7/30 to 8/14/89 (C) 7/31 to 8/15/89
Weighed (4dg) started exposure	(A-C) 7/29 to 7/31/89
Weighed (6dg)	(A-C) 7/31 to 8/2/89
Weighed (10dg)	(A-C) 8/4 to 8/6/89
Weighed (14dg)	(A-C) 8/8 to 8/10/89
Weighed (17dg)	(A-C) 8/11 to 8/13/89
Distribution sacrifice (7dg)	(B-dist) 8/2/89
(14dg)	(B-dist) 8/9/89
(20dg)	(B-dist) 8/15/89
Teratology sacrifice (20dg)	(A) 8/14/89 (B) 8/15/89 (C) 8/16/89
Virgins - exposed	8/1 to 8/16/89
Selected and individually caged	7/24/89
Weighed and randomized	7/31/89
Weighed (exposure day 1) started exposure	8/1/89
Weighed (exposure day 3)	8/3/89
Weighed (exposure day 7)	8/7/89
Weighed (exposure day 11)	8/11/89
Weighed (exposure day 14)	8/14/89
Sacrificed	8/17/89
Fetal specimen exams completed	12/20/89

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents:
CALENDAR OF EVENTS OF MALE RATS

Received male rats (ARS#890063)	6/20/89
Health screen	7/10/89
Tail tattoo males	7/13/89
Released from quarantine	7/18/89
Initiated breeding	7/24 to 7/26/89
Acclimated in exposure caging	7/28/89
Weighed and randomized	8/3/89
Moved to exposure room	8/5/89
Exposure (6 hours/day; 7 days/week)	8/5 to 8/16/89
Weighed	8/5/89
Weighed	8/17/89
Sacrifice, tissue distribution and sperm evaluation	8/17/89

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents:
CALENDAR OF EVENTS OF FEMALE MICE

Received mice (ARS#890064)	6/20/89
Health screen	7/10/89
Tail tattoo females	7/11/89
Released from quarantine	7/18/89
Weighed female mice	7/20/89
0dg (# positive) weighed, randomized and individually caged	(A) 7/21/89 (28) (B) 7/22/89 (38) (C) 7/23/89 (27 on study)
Moved to exposure room (4dg)	(A) 7/25/89 (B) 7/26/89 (C) 7/27/89
Exposure (6 hours/day; 7 days/week; 4-17dg)	(A) 7/25 to 8/7/89 (B) 7/26 to 8/8/89 (C) 7/27 to 8/9/89
Weighed (4dg) started exposure	(A-C) 7/25 to 7/27/89
Weighed (6dg)	(A-C) 7/27 to 7/29/89
Weighed (9dg)	(A-C) 7/30 to 8/1/89
Weighed (12dg)	(A-C) 8/2 to 8/4/89
Weighed (15dg)	(A-C) 8/5 to 8/7/89
Teratology sacrifice (18dg)	(A) 8/8/89 (B) 8/9/89 (C) 8/10/89
Virgins - exposed	7/25 to 8/7/89
Selected, randomized, and individually caged	7/20/89
Weighed (exposure day 1) started exposure	7/25/89
Weighed (exposure day 3)	7/27/78
Weighed (exposure day 9)	8/2/89
Weighed (exposure day 12)	8/5/89
Sacrificed	8/8/89
Fetal specimen exams completed	10/23/89

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents:
CALENDAR OF EVENTS OF MALE MICE

Received male mice (ARS#890064)	6/20/89
Health screen	7/10/89
Tail tattoo males	7/11/89
Released from quarantine	7/18/89
Initiated breeding	7/20 to 7/22/89
Acclimated in exposure caging	7/23/89
Weighed and randomized	8/3/89
Moved to exposure room	8/5/89
Exposure (6 hours/day; 7 days/week)	8/5 to 8/16/89
Weighed	8/5/89
Weighed	8/17/89
Sacrifice, tissue distribution and sperm evaluation	8/18/89

Maternal Body and Organ Weights

Gallium Arsenide Rat Teratology Study: Body and Organ Weights (g) for Sperm-positive Females

TMT=0 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	0 dg Wt (g)	4 dg Wt (g)	6 dg Wt (g)	10 dg Wt (g)	14 dg Wt (g)	17 dg Wt (g)	20 dg Wt (g)	Uter Wt (g)	Liver Wt (g)	Kidney Wt (g)	Pregnant
364	307.1	294.0	337.0	346.4	365.1	379.2	404.8	444.8	87.26	16.592	2.322	1
369	310.0	310.0	331.8	327.0	342.0	364.3	400.3	450.4	90.04	18.701	2.409	1
372	276.5	273.1	309.2	314.6	327.9	355.8	378.2	421.5	74.54	17.260	2.389	1
384	294.3	295.3	325.6	322.6	345.7	371.8	384.9	411.8	71.26	15.429	2.116	1
391	247.9	245.9	280.6	275.4	293.1	322.0	344.1	384.0	86.13	16.321	1.874	1
431	296.3	292.4	317.4	318.8	335.4	359.2	384.2	437.8	109.51	16.628	2.181	1
437	306.4	305.0	333.0	338.2	350.0	362.1	338.7	323.4	0.85	13.801	2.333	0
447	.	283.3	301.6	307.1	317.4	338.0	370.2	422.6	96.89	16.268	2.161	1
465	261.6	265.4	296.7	302.4	313.8	333.0	360.6	397.2	77.50	16.052	2.276	1
466	286.4	287.7	322.9	330.9	352.7	382.3	418.1	469.9	84.62	19.882	2.682	1
484	279.9	275.2	308.2	304.1	328.8	341.1	320.2	329.4	0.96	15.571	2.640	0
502	286.6	277.3	316.3	317.2	340.0	349.2	337.2	325.7	0.83	12.453	2.422	0
523	284.8	276.4	303.8	303.8	306.0	314.9	308.4	293.8	0.69	11.347	2.945	0
530	312.5	319.5	347.2	353.7	363.3	380.3	385.6	403.3	17.99	16.333	2.730	1
531	260.2	262.6	281.0	286.7	303.2	305.5	338.9	350.1	83.40	13.456	2.122	1
536	302.3	300.6	328.5	331.9	350.0	363.6	393.0	441.4	88.60	15.831	2.274	1
542	300.7	292.1	323.4	333.0	354.5	372.3	402.3	439.3	88.40	18.623	2.282	1
560	288.4	289.1	319.2	321.9	330.3	350.9	385.0	422.5	92.05	17.091	2.346	1
606	263.3	265.3	287.2	293.2	305.0	315.5	339.9	361.7	44.86	15.291	2.536	1
619	302.8	307.4	336.2	344.1	362.7	375.0	408.7	453.3	82.42	20.943	2.471	1
623	281.8	284.7	298.9	306.3	320.0	338.1	361.8	402.3	87.35	18.445	2.399	1
624	290.6	288.2	307.5	311.1	323.6	350.3	373.1	405.9	77.56	16.638	2.513	1
634	260.9	258.5	282.8	285.4	305.9	324.5	351.5	392.0	76.39	17.084	1.887	1
638	277.0	280.8	309.3	314.9	327.7	312.3	309.2	279.6	0.65	9.438	2.130	0
643	273.9	270.7	294.4	296.2	312.0	319.4	340.8	375.3	69.26	15.324	2.227	1
653	276.5	281.8	305.9	299.4	314.7	333.0	359.1	405.4	80.27	15.607	2.351	1
654	317.2	314.3	351.4	357.4	367.5	393.6	424.7	478.8	91.72	18.560	2.387	1
659	306.4	301.4	331.4	327.6	349.1	369.7	393.7	434.6	72.64	17.151	2.311	1
689	303.9	307.6	329.2	330.8	355.4	400.0	435.9	498.3	101.41	23.023	2.578	1
707	265.1	261.2	283.9	282.6	304.1	333.3	370.3	417.9	71.41	19.682	2.253	1

Code for Pregnant Column: 1=Pregnant 0=Non-Pregnant

Gallium Arsenide Rat Teratology Study: Body and Organ Weights (g) for Sperm-positive Females

TMT=10 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	0 dg Wt (g)	4 dg Wt (g)	6 dg Wt (g)	10 dg Wt (g)	14 dg Wt (g)	17 dg Wt (g)	20 dg Wt (g)	Uter Wt (g)	Liver Wt (g)	Kidney Wt (g)	Pregnant
367	282.0	280.4	313.0	321.1	335.5	341.9	327.5	334.1	1.03	15.265	2.551	0
380	298.2	297.2	327.3	333.7	360.2	391.5	416.2	461.5	83.61	19.001	2.453	1
382	262.7	255.3	274.4	272.8	284.0	315.5	348.5	395.8	90.92	16.734	2.217	1
403	292.8	285.2	320.5	327.4	334.0	349.1	325.9	330.2	0.88	12.470	2.227	0
438	276.8	274.0	307.3	316.0	324.5	350.7	379.4	407.0	75.29	15.930	2.122	1
443	300.7	289.6	324.2	320.0	328.3	351.5	370.1	403.2	71.66	15.349	2.245	1
458	289.7	288.5	318.3	333.8	343.7	337.3	334.0	327.6	0.71	12.576	2.788	0
480	279.2	276.6	303.8	307.4	319.9	341.4	371.5	408.9	74.24	16.268	2.134	1
495	283.8	283.1	315.8	318.4	328.3	344.3	362.2	384.8	35.19	18.394	2.694	1
520	296.4	302.2	314.2	320.3	332.0	355.2	373.2	384.5	60.13	14.635	2.067	1
562	322.9	316.0	336.0	331.0	341.0	364.9	394.9	440.4	97.90	17.125	2.197	1
583	314.0	308.1	345.0	352.4	368.0	396.2	421.7	471.9	78.32	19.939	2.605	1
597	300.3	303.6	335.4	344.4	364.3	387.3	417.4	479.7	97.48	18.312	2.637	1
602	270.7	273.2	301.6	305.7	318.8	330.4	339.0	352.7	19.11	19.089	2.658	1
610	296.5	292.6	324.8	336.6	356.2	379.1	419.4	472.0	97.09	20.913	2.484	1
614	326.4	329.5	368.4	375.5	390.3	404.6	433.6	488.2	102.17	19.311	2.431	1
616	290.8	288.9	316.5	319.3	325.7	355.4	371.5	426.6	93.07	17.435	2.385	1
629	269.4	269.5	285.3	291.2	310.1	336.1	358.1	385.8	82.93	16.283	2.181	1
633	307.8	302.4	340.2	345.6	352.1	368.7	353.2	343.0	0.68	14.911	2.567	0
635	303.7	298.8	332.0	338.4	352.5	380.5	415.1	472.3	93.06	19.989	2.582	1
645	315.8	314.9	339.2	340.6	361.4	393.9	421.1	464.6	77.94	19.947	2.608	1
649	270.2	276.7	297.3	301.1	309.6	332.7	360.5	411.6	86.76	17.144	2.183	1
656	285.9	283.2	321.8	319.3	339.2	358.8	389.0	440.1	90.26	18.666	2.431	1
672	291.4	291.2	311.5	315.0	338.1	358.8	380.3	419.6	74.59	18.062	2.448	1
677	274.8	275.7	301.4	304.6	305.1	329.8	351.6	382.1	71.47	15.657	2.347	1
679	264.3	260.6	284.7	290.0	309.7	330.3	348.9	393.2	76.65	16.776	2.071	1
684	298.8	294.6	321.0	295.6	285.7	342.2	365.7	420.9	89.75	17.458	2.617	1
694	258.1	256.0	272.9	277.5	287.7	301.4	306.7	330.8	67.97	13.526	1.731	1
697	274.2	276.1	298.6	307.3	327.2	340.7	367.8	408.8	82.84	19.765	2.266	1
706	269.1	274.0	291.7	301.4	312.1	338.5	369.3	418.4	86.97	16.707	2.189	1
716	268.8	268.1	301.2	298.1	311.5	337.3	361.0	406.2	82.52	16.903	2.294	1

Code for Pregnant Column: 1=Pregnant 0=Non-Pregnant

Gallium Arsenide Rat Teratology Study: Body and Organ Weights (g) for Sperm-positive Females

TMT=37 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	0 dg Wt (g)	4 dg Wt (g)	6 dg Wt (g)	10 dg Wt (g)	14 dg Wt (g)	17 dg Wt (g)	20 dg Wt (g)	Uter Wt (g)	Liver Wt (g)	Kidney Wt (g)	Pregnant
370	305.5	302.0	330.3	329.4	349.1	378.7	393.2	438.3	75.05	19.730	2.856	1
377	270.9	268.9	292.2	294.9	297.2	322.8	344.9	390.6	80.23	14.746	2.120	1
381	304.7	288.4	311.0	319.2	333.4	356.7	382.6	422.6	76.43	16.922	2.439	1
398	281.1	281.8	308.3	308.4	322.2	344.1	361.7	394.4	52.83	16.270	2.518	1
492	279.9	285.6	315.2	322.9	339.5	362.7	395.3	444.0	79.55	18.874	2.268	1
496	302.7	308.0	336.1	345.0	353.8	366.9	390.7	436.3	87.58	16.757	2.347	1
525	334.1	333.0	345.5	350.8	375.2	403.5	440.7	483.6	76.46	22.720	2.705	1
543	309.6	294.0	321.5	330.5	354.4	378.9	412.1	457.4	85.13	20.311	2.434	1
558	304.8	305.7	330.2	350.6	373.7	395.0	430.3	472.8	87.00	22.548	2.668	1
561	334.3	325.0	351.1	364.5	380.2	379.2	363.8	374.8	1.00	18.868	3.005	0
571	296.8	297.1	325.4	328.5	337.8	365.6	402.5	453.7	93.86	17.512	2.362	1
575	295.8	304.5	325.9	337.9	359.5	373.1	403.8	450.6	86.60	17.729	2.332	1
587	299.8	291.2	317.1	325.0	346.8	363.1	389.0	430.8	78.80	19.119	2.559	1
591	269.5	266.7	287.3	279.8	298.2	320.5	346.5	380.9	72.31	16.704	1.956	1
593	292.3	291.3	317.9	328.9	337.9	364.2	399.1	458.3	108.03	18.573	2.605	1
594	286.1	284.5	308.6	313.0	329.7	351.2	378.3	425.9	68.10	15.682	2.431	1
598	291.4	285.3	313.6	317.5	330.2	351.3	374.8	416.8	71.17	16.133	2.130	1
599	279.2	280.8	308.7	312.1	324.2	347.8	364.6	397.4	72.08	16.709	2.584	1
608	264.3	260.1	288.3	294.8	309.6	338.3	367.6	419.5	86.53	16.958	2.308	1
617	256.4	253.8	280.4	290.3	305.7	327.0	347.9	391.7	88.07	18.104	2.130	1
626	301.2	295.8	332.1	333.9	338.9	364.8	386.2	413.6	48.12	17.060	2.404	1
639	298.0	291.5	324.7	328.3	343.0	379.0	408.7	457.5	84.19	18.034	2.357	1
644	275.5	275.8	301.8	306.0	318.9	346.0	380.0	435.1	92.10	18.367	2.378	1
650	253.9	252.2	280.3	285.1	294.4	321.0	351.1	398.4	90.90	16.596	2.097	1
652	265.8	274.5	297.8	301.8	307.3	334.7	359.6	410.8	76.50	16.843	2.273	1
661	306.8	310.2	335.7	339.7	353.2	372.2	399.4	437.8	64.11	16.652	2.533	1
678	269.9	275.7	304.8	322.4	340.8	357.5	354.4	358.7	0.41	18.048	2.515	0
683	282.3	287.9	312.5	318.7	336.4	357.7	384.3	434.2	88.92	18.454	2.392	1
708	267.0	262.4	281.6	285.2	304.7	321.1	356.6	393.9	71.93	17.628	2.049	1
721	276.4	277.9	300.2	309.3	317.2	341.0	364.5	415.2	80.94	16.945	2.262	1

Code for Pregnant Column: 1=Pregnant 0=Non-Pregnant

Gallium Arsenide Rat Teratology Study: Body and Organ Weights (g) for Sperm-positive Females

TMT=75 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	0 dg Wt (g)	4 dg Wt (g)	6 dg Wt (g)	10 dg Wt (g)	14 dg Wt (g)	17 dg Wt (g)	20 dg Wt (g)	Uter Wt (g)	Liver Wt (g)	Kidney Wt (g)	Pregnant
389	272.7	273.8	298.6	305.3	313.5	331.8	350.2	395.7	69.35	16.695	2.131	1
407	297.6	295.0	319.0	315.1	328.0	346.5	376.6	416.5	70.33	16.259	2.564	1
411	295.2	291.2	322.2	319.0	333.6	352.9	378.0	422.5	95.08	17.371	2.044	1
421	279.3	276.7	307.4	311.4	328.0	351.4	387.5	438.6	81.64	18.993	2.464	1
442	303.3	297.6	311.5	302.4	306.5	304.5	301.0	302.9	0.76	12.383	2.216	0
446	284.3	282.8	308.7	309.9	318.4	343.6	379.1	437.6	92.31	18.854	2.896	1
457	277.1	276.3	299.8	304.6	319.7	336.1	337.0	333.4	8.05	11.753	2.298	1
474	278.4	275.0	308.8	307.3	313.6	321.0	316.9	388.6	75.40	16.339	2.127	1
494	285.7	285.9	319.0	326.3	344.8	361.1	391.2	412.1	80.92	15.346	2.752	1
499	298.6	294.9	328.4	334.4	347.9	373.8	403.9	463.8	88.56	19.597	2.469	1
518	255.7	260.5	285.0	292.9	303.1	328.0	361.1	406.2	77.95	18.205	2.205	1
535	322.0	315.1	346.2	339.4	337.2	353.7	357.3	354.5	0.72	12.927	2.406	0
574	293.8	288.9	317.4	322.5	340.8	351.4	383.9	422.0	85.88	19.613	2.668	1
584	296.6	297.5	334.0	335.5	348.2	380.0	416.0	480.0	102.77	19.405	2.545	1
603	278.5	284.4	313.1	316.0	326.3	355.7	374.9	406.6	63.95	17.186	2.327	1
631	306.7	311.0	340.2	349.0	364.8	390.0	415.6	461.6	83.90	20.429	2.519	1
642	297.4	298.7	333.0	335.7	344.8	360.6	396.1	440.1	88.68	17.719	2.190	1
663	310.8	308.7	340.0	335.5	347.0	362.8	387.5	420.9	57.62	16.655	2.556	1
667	271.8	271.2	295.1	303.1	320.8	336.1	367.1	411.2	81.05	16.864	2.237	1
678	287.3	284.5	317.5	315.8	323.5	349.5	379.1	432.0	87.90	17.405	2.139	1
687	299.8	301.8	344.8	347.0	363.1	386.1	405.8	432.2	14.14	20.055	2.863	1
698	269.8	268.1	288.7	300.5	317.6	327.5	355.6	395.9	77.13	16.815	2.033	1
702	271.5	270.7	302.3	307.6	327.3	346.7	357.0	379.9	19.07	17.594	2.678	1
710	292.6	280.4	303.9	310.3	317.9	338.2	364.2	398.9	64.20	13.927	2.094	1
711	259.8	259.9	291.7	295.7	314.9	329.9	353.1	396.7	68.09	16.757	2.117	1
712	305.2	298.0	329.5	338.4	360.2	383.0	416.5	460.0	87.70	19.658	2.196	1
714	255.5	252.0	276.8	284.6	292.5	312.2	338.7	384.1	82.81	15.448	2.085	1
717	294.4	296.1	328.7	339.0	361.6	388.2	418.2	469.8	82.77	20.324	2.482	1
719	314.1	309.5	341.3	351.9	361.5	389.0	412.9	455.0	59.41	19.233	2.942	1
723	260.0	257.5	281.9	283.5	298.6	319.0	349.9	383.3	80.78	16.685	2.151	1

Code for Pregnant Column: 1=Pregnant 0=Non-Pregnant

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Body and Organ Weights (g) for Plug-positive Female Mice

TMT=0 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	0 dg Wt (g)	4 dg Wt (g)	6 dg Wt (g)	9 dg Wt (g)	12 dg Wt (g)	15 dg Wt (g)	18 dg Wt (g)	Uter Wt (g)	Liver Wt (g)	Kidney Wt (g)	Pregnant
10	29.0	27.9	29.6	29.80	32.6	36.9	44.3	52.3	18.81	2.730	0.382	1
35	30.6	29.0	30.9	31.80	33.8	41.0	51.2	61.4	23.77	2.937	0.436	1
44	30.1	28.2	28.3	29.40	31.7	37.8	46.5	55.9	21.07	2.656	0.382	1
49	30.0	29.0	28.8	29.00	31.1	35.9	43.9	51.6	20.91	2.286	0.393	1
154	25.4	24.6	24.3	24.60	26.1	26.3	27.2	25.9	0.20	1.472	0.367	0
158	32.1	31.3	32.5	31.80	33.9	38.8	46.3	55.4	19.58	2.555	0.377	1
159	30.0	30.2	29.1	29.80	32.4	38.2	45.9	54.7	18.91	2.795	0.486	1
186	26.3	25.6	26.1	26.00	26.4	26.7	26.3	26.7	0.17	1.509	0.383	0
188	26.9	26.4	28.8	30.20	29.7	29.9	30.1	30.3	0.17	2.109	0.484	0
190	27.8	27.8	27.7	27.70	29.3	30.8	33.4	35.9	4.43	2.248	0.389	1
191	30.8	29.8	31.8	32.90	32.9	38.6	44.7	52.1	18.36	2.593	0.524	1
194	28.9	27.8	28.3	28.90	29.9	35.1	42.1	50.6	17.35	2.795	0.466	1
202	31.7	29.2	31.0	31.00	32.8	38.5	46.1	57.1	21.88	3.042	0.494	1
212	32.9	31.8	31.9	32.70	35.4	41.5	50.2	58.8	22.81	3.023	0.456	1
240	31.5	30.5	31.6	31.80	33.8	40.4	47.5	59.2	21.47	3.348	0.496	1
266	30.2	29.2	29.1	29.22	31.2	36.6	43.4	53.7	20.57	2.640	0.488	1
276	26.0	25.9	26.9	27.60	26.7	26.3	26.6	27.5	0.24	1.557	0.386	0
290	29.1	29.3	28.6	29.50	32.6	38.4	47.2	56.8	20.49	2.839	0.433	1
309	34.1	32.1	33.3	34.00	33.7	40.9	48.4	58.2	20.04	3.480	0.477	1
315	29.0	28.0	29.1	29.20	31.6	36.2	45.6	57.2	24.10	2.471	0.467	1
319	31.1	30.7	31.2	31.90	31.7	32.3	31.5	31.6	0.32	1.968	0.582	0
330	31.3	29.8	30.6	30.50	30.0	29.4	28.1	28.4	0.23	1.999	0.439	0
334	30.1	28.5	30.1	31.50	33.8	40.9	50.5	61.0	23.83	3.041	0.519	1

Code for Pregnant Column: 1=Pregnant 0=Non-Pregnant

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Body and Organ Weights (g) for Plug-positive Female Mice

TMT=10 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	0 dg Wt (g)	4 dg Wt (g)	6 dg Wt (g)	9 dg Wt (g)	12 dg Wt (g)	15 dg Wt (g)	18 dg Wt (g)	Uter Wt (g)	Liver Wt (g)	Kidney Wt (g)	Pregnant
3	32.9	30.7	30.7	31.8	32.3	38.7	48.0	60.5	24.27	2.960	0.478	1
9	33.2	31.6	31.4	32.3	31.8	36.4	43.4	51.7	15.59	2.465	0.465	1
16	30.5	29.8	29.3	31.3	28.6	36.2	44.9	54.4	19.92	2.664	0.456	1
38	27.8	27.5	28.0	27.6	27.8	32.4	38.2	46.2	14.99	2.276	0.340	1
48	33.2	31.3	33.3	34.2	31.1	34.8	48.6	58.6	22.30	3.074	0.531	1
52	28.9	26.6	28.3	29.3	30.3	31.7	40.7	52.1	17.93	2.768	0.483	1
70	25.9	25.9	27.9	28.7	29.2	34.3	41.9	50.4	17.15	2.796	0.402	1
91	32.1	31.1	32.4	32.6	33.0	39.9	49.6	60.6	21.01	3.615	0.453	1
94	28.2	27.4	28.6	28.5	28.6	31.7	37.6	46.5	14.62	2.643	0.443	1
116	28.8	28.5	30.5	31.7	32.9	38.8	46.1	54.3	18.51	2.434	0.416	1
118	32.3	30.2	31.5	34.4	34.4	40.8	51.1	63.0	22.36	3.324	0.690	1
120	29.5	28.2	29.8	31.3	33.5	39.0	48.7	60.0	21.70	3.020	0.511	1
127	29.4	28.1	28.4	30.2	29.3	35.6	44.2	55.3	20.38	2.914	0.404	1
176	30.2	28.6	30.4	31.9	33.4	40.1	49.7	58.5	23.34	2.804	0.483	1
182	30.8	29.8	31.6	32.7	30.8	37.1	46.7	59.6	23.67	3.003	0.442	1
209	29.8	29.1	28.7	30.6	28.6	30.0	32.0	31.2	0.21	1.927	0.506	1
250	30.4	29.9	29.8	32.1	33.8	39.2	46.8	57.2	21.69	3.338	0.528	1
254	32.1	32.4	33.4	34.9	35.3	40.1	46.0	58.5	20.57	2.919	0.487	1
255	27.9	27.9	27.8	27.5	27.4	28.3	27.3	28.2	0.27	1.695	0.390	0
278	29.4	29.1	29.2	30.4	30.7	35.3	42.2	50.2	16.18	2.858	0.450	1
292	28.4	28.2	28.6	28.5	25.9	27.6	27.4	28.3	0.34	1.714	0.400	1
297	29.6	29.1	30.1	29.7	25.2	27.6	29.0	29.4	0.24	1.653	0.435	0
308	31.1	30.0	30.2	31.4	32.7	37.0	44.8	55.6	20.83	3.179	0.490	1
318	28.9	27.6	29.1	30.0	31.0	33.6	43.4	50.4	16.98	2.930	0.460	1

Code for Pregnant Column: 1=Pregnant 0=Non-Pregnant

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Body and Organ Weights (g) for Plug-positive Female Mice

TMT=37 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	0 dg Wt (g)	4 dg Wt (g)	6 dg Wt (g)	9 dg Wt (g)	12 dg Wt (g)	15 dg Wt (g)	18 dg Wt (g)	Uter Wt (g)	Liver Wt (g)	Kidney Wt (g)	Pregnant
33	28.6	27.9	28.1	29.3	25.2	.	.	.	.	.	.	.
39	31.4	27.9	29.3	29.6	31.0	35.7	44.1	52.6	18.41	2.923	0.493	1
43	29.0	27.6	28.2	29.3	27.9	33.9	40.4	49.0	16.74	0.464	2.721	1
56	32.1	28.8	28.7	29.7	27.6	31.8	40.0	49.9	18.09	2.588	0.408	1
83	34.2	32.7	34.2	34.4	31.7	27.0	34.6	38.1	1.40	2.680	0.433	1
96	32.1	30.3	31.4	31.8	27.9	29.8	30.8	30.4	0.11	2.108	0.503	0
110	27.5	26.2	29.4	30.0	31.0	32.8	42.6	50.8	15.42	3.000	0.523	1
112	31.6	31.2	32.1	34.3	30.4	.	.	.	.	.	.	.
150	33.0	32.4	33.2	33.8	31.9	38.2	47.2	58.6	19.76	3.404	0.528	1
166	29.1	28.5	29.8	29.9	26.9	33.1	38.6	45.6	12.70	2.759	0.433	1
204	30.8	29.8	29.8	30.0	30.2	33.8	43.6	53.7	19.08	3.073	0.476	1
216	27.7	27.2	28.2	29.2	29.6	33.9	41.4	49.6	16.06	2.822	0.444	1
217	29.2	28.3	28.6	30.2	22.6	.	.	.	.	.	.	.
223	31.7	30.7	30.9	30.7	27.5	26.5	30.1	31.5	0.21	2.214	0.442	1
237	28.2	27.8	27.8	29.0	26.9	32.5	40.1	49.6	16.68	2.763	0.499	1
270	30.4	29.5	30.5	29.8	26.7	34.8	44.4	57.8	23.16	2.824	0.451	1
289	27.5	27.3	27.3	28.6	21.1	26.6	26.6	26.6	0.23	1.777	0.397	1
301	26.9	26.7	26.1	26.2	20.5	.	.	.	.	.	.	.
310	31.6	30.0	30.2	31.6	31.4	37.3	46.1	57.6	22.49	3.097	0.485	1
324	29.5	29.4	29.3	32.3	31.6	38.3	45.3	55.2	20.15	3.134	0.522	1
343	31.2	29.8	29.8	31.3	.	.	.	.	.	.	.	.
350	31.5	29.3	30.2	30.2	28.2	28.9	29.9	28.8	0.15	1.691	0.423	1

Code for Pregnant Column: 1=Pregnant 0=Non-Pregnant

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Body and Organ Weights (g) for Plug-positive Female Mice

TMT=75 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	0 dg Wt (g)	4 dg Wt (g)	6 dg Wt (g)	9 dg Wt (g)	12 dg Wt (g)	15 dg Wt (g)	18 dg Wt (g)	Uter Wt (g)	Liver Wt (g)	Kidney Wt (g)	Pregnant
17	28.1	26.9	26.8	27.8	21.9	25.8	26.5	26.6	0.31	1.528	0.399	0
27	32.3	31.2	31.9	31.6	29.1	30.9	30.5	30.2	0.26	1.934	0.546	1
31	27.6	27.2	29.1	30.1	24.0	.	.	.	.	.	.	.
34	30.6	29.4	29.7	29.5	26.2	26.2	28.3	29.0	0.29	1.796	0.390	1
84	28.7	27.9	29.2	30.4	.	.	.	.	.	.	.	.
88	32.1	30.5	31.1	30.3	29.7	34.1	41.9	49.9	13.98	3.016	0.406	1
106	30.9	30.9	31.3	32.2	29.8	32.7	42.5	51.5	17.21	2.867	0.467	1
114	31.0	30.3	32.0	32.6	27.8	25.3	30.9	32.1	0.38	1.963	0.441	1
133	29.3	28.3	23.5	26.6	22.1	.	.	.	.	.	.	.
151	30.2	29.1	28.7	29.7	25.0	.	.	.	.	.	.	.
164	30.7	29.8	29.6	29.2	23.9	26.4	27.7	27.7	0.18	1.468	0.377	1
167	27.5	26.6	26.4	26.9	26.4	29.1	38.4	49.8	17.61	2.916	0.478	1
168	30.3	30.5	32.9	33.6	32.2	40.8	51.0	61.2	23.84	3.103	0.392	1
172	29.4	27.6	29.0	31.0	25.7	24.0	26.8	28.0	0.29	1.661	0.428	0
185	31.2	29.7	30.2	29.4	25.4	.	.	.	.	.	.	.
205	30.6	29.5	29.9	30.4	24.8	29.1	32.9	38.0	3.80	2.469	0.489	1
210	31.1	29.8	30.5	31.9	31.6	37.8	48.1	54.7	18.85	3.197	0.493	1
229	26.8	25.9	25.6	26.6	26.0	.	.	.	.	.	.	.
238	29.8	28.5	29.2	30.1	24.2	27.2	29.7	29.8	0.18	1.804	0.432	1
264	29.5	28.1	28.6	29.3	25.7	27.0	28.1	27.8	0.29	1.681	0.446	1
280	30.7	29.8	31.5	30.3	29.0	30.3	31.3	30.1	0.24	2.076	0.540	1
299	27.1	27.7	30.0	29.7	26.0	.	.	.	.	.	.	.
332	30.2	29.3	31.5	32.5	26.2	.	.	.	.	.	.	.
346	31.4	28.6	29.6	30.6	27.7	34.1	44.2	56.4	21.39	2.692	0.476	1

Code for Pregnant Column: 1=Pregnant 0=Non-Pregnant

Virgin Body and Organ Weights

Inhalation Developmental Toxicity Study in Rodents: Body and Organ Weights(g) for Virgin Rats

TMT=0 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	Exposure Day 1 Wt (g)	Exposure Day 3 Wt (g)	Exposure Day 7 Wt (g)	Exposure Day 11 Wt (g)	Exposure Day 14 Wt (g)	Sacrifice Wt (g)	Liver Wt (g)	Kidney Wt (g)
417	257.5	264.7	268.3	277.9	293.7	284.3	280.7	11.584	1.877
482	280.8	280.9	288.4	288.2	293.2	290.9	299.4	11.103	2.457
509	312.1	314.0	309.2	311.4	316.6	320.4	324.9	13.653	2.574
533	316.9	310.1	311.9	321.2	316.1	330.0	319.7	13.783	2.216
547	293.0	290.3	301.1	313.4	323.3	316.9	314.1	14.033	2.502
582	284.1	283.2	288.8	295.7	289.7	294.3	294.8	13.041	2.444
588	329.4	327.5	336.9	360.7	363.9	358.9	351.5	12.946	2.552
592	343.2	338.9	342.7	354.4	362.4	358.8	369.7	16.048	2.795
620	310.6	305.1	313.6	314.5	318.8	313.4	319.2	13.184	2.438
727	289.0	282.2	291.6	293.3	295.6	293.3	292.2	12.926	2.401

Inhalation Developmental Toxicity Study in Rodents: Body and Organ Weights(g) for Virgin Rats

TMT=10 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	Exposure Day 1 Wt (g)	Exposure Day 3 Wt (g)	Exposure Day 7 Wt (g)	Exposure Day 11 Wt (g)	Exposure Day 14 Wt (g)	Sacrifice Wt (g)	Liver Wt (g)	Kidney Wt (g)
366	251.5	256.1	262.6	273.6	274.1	284.3	269.1	11.962	2.420
379	321.9	326.6	323.6	337.7	358.4	363.1	361.1	15.643	2.924
401	283.3	284.1	292.6	301.4	294.6	296.9	288.3	13.866	2.118
429	325.2	325.4	321.5	327.8	333.1	346.3	354.6	18.099	2.747
477	274.0	275.0	276.6	275.9	279.7	287.2	289.7	11.373	2.035
486	315.5	324.1	333.2	342.9	353.6	356.0	350.8	17.249	2.742
607	302.2	299.5	304.7	311.3	336.4	333.6	340.1	17.366	2.846
625	292.4	293.1	293.0	300.4	306.0	306.9	315.8	16.986	2.487
632	308.4	308.4	306.8	299.9	302.9	318.0	323.8	16.002	2.598
709	345.9	340.7	327.6	317.5	312.0	323.5	321.0	15.917	2.516

Inhalation Developmental Toxicity Study in Rodents: Body and Organ Weights(g) for Virgin Rats

TMT=37 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	Exposure Day 1 Wt (g)	Exposure Day 3 Wt (g)	Exposure Day 7 Wt (g)	Exposure Day 11 Wt (g)	Exposure Day 14 Wt (g)	Sacrifice Wt (g)	Liver Wt (g)	Kidney Wt (g)
378	300.3	304.0	298.0	295.3	303.5	316.3	318.4	16.019	2.618
444	293.0	292.1	294.2	291.9	294.9	299.4	304.1	15.364	2.200
493	285.7	287.8	279.7	283.8	298.5	303.0	302.9	15.155	2.594
517	256.4	256.4	260.6	265.1	270.3	284.0	289.4	14.067	2.351
529	315.5	317.4	305.5	302.0	309.6	322.9	321.2	15.723	2.674
546	305.0	309.5	309.6	309.4	319.9	320.2	318.9	15.728	2.872
657	332.5	326.7	330.1	317.3	336.5	343.4	337.9	15.970	2.710
658	365.9	366.1	362.9	367.4	375.3	375.2	393.0	19.311	3.198
703	317.8	326.0	331.1	341.1	351.3	351.2	361.2	18.219	2.806
728	273.1	272.0	275.9	280.1	284.8	278.6	287.8	14.697	2.276

Inhalation Developmental Toxicity Study in Rodents: Body and Organ Weights(g) for Virgin Rats

TMT=75 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	Exposure Day 1 Wt (g)	Exposure Day 3 Wt (g)	Exposure Day 7 Wt (g)	Exposure Day 11 Wt (g)	Exposure Day 14 Wt (g)	Sacrifice Wt (g)	Liver Wt (g)	Kidney Wt (g)
405	258.1	260.9	258.4	267.4	272.8	283.9	287.2	12.984	2.533
472	323.4	321.2	312.8	309.8	316.0	324.3	315.7	11.769	2.267
504	316.4	315.4	312.4	316.0	331.6	323.8	334.4	14.308	2.422
527	311.5	304.2	303.3	304.4	311.1	307.8	313.3	14.769	2.451
540	343.9	343.7	346.3	342.3	345.6	344.6	345.1	18.412	3.077
627	255.4	265.9	265.8	272.2	276.5	282.3	277.8	13.400	2.400
637	301.5	313.4	306.9	316.5	323.7	316.4	315.4	14.003	2.454
685	329.7	340.5	326.4	332.8	332.8	339.7	347.6	15.220	2.665
695	291.2	301.8	301.2	307.5	313.3	314.6	319.0	15.953	2.499
715	286.1	286.3	281.5	278.8	281.1	288.6	291.3	13.847	2.632

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Body and Organ Weights (g) for Virgin Mice

TMT=0 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	Exposure Day 1 Wt (g)	Exposure Day 3 Wt (g)	Exposure Day 6 Wt (g)	Exposure Day 9 Wt (g)	Exposure Day 12 Wt (g)	Sacrifice Wt (g)	Liver Wt (g)	Kidney Wt (g)
2	32.1	32.2	32.6	32.3	36.5	33.8	33.2	1.987	0.459
22	28.6	27.6	27.2	27.3	30.9	29.3	26.8	1.440	0.373
42	28.3	27.2	27.9	28.6	31.4	29.1	28.9	1.727	0.382
126	29.1	29.2	28.0	29.4	32.9	30.0	29.0	1.711	0.389
132	29.5	29.7	29.6	28.8	31.8	29.6	28.3	1.619	0.386
140	29.9	28.2	27.6	27.1	31.8	29.8	28.0	1.775	0.473
173	32.6	33.0	31.2	33.7	35.5	34.3	30.7	1.914	0.463
177	31.0	30.3	30.9	30.7	30.4	30.0	30.1	1.564	0.460
181	31.6	29.9	30.0	29.8	30.1	30.3	29.6	1.812	0.424
302	26.6	27.4	27.0	27.5	26.8	27.7	27.0	1.651	0.411

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Body and Organ Weights (g) for Virgin Mice

TMT=10 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	Exposure Day 1 Wt (g)	Exposure Day 3 Wt (g)	Exposure Day 6 Wt (g)	Exposure Day 9 Wt (g)	Exposure Day 12 Wt (g)	Sacrifice Wt (g)	Liver Wt (g)	Kidney Wt (g)
8	29.6	27.5	29.7	27.4	24.7	27.3	27.7	1.650	0.417
46	30.6	28.9	31.3	27.0	30.0	31.1	29.8	1.736	0.402
107	34.6	31.1	34.1	31.6	27.0	31.4	32.2	1.987	0.489
130	29.4	28.8	30.2	24.7	24.3	28.5	28.1	1.593	0.349
180	26.8	27.3	27.9	27.9	27.9	27.1	26.9	1.613	0.393
195	26.7	26.7	26.8	24.5	24.6	25.3	26.4	1.713	0.360
228	31.2	30.7	30.6	28.3	22.9	27.6	30.1	2.103	0.397
234	28.3	27.5	29.1	25.3	27.6	26.3	27.5	1.617	0.369
325	28.9	29.0	30.4	26.7	26.0	27.5	28.2	1.840	0.437
335	32.2	31.0	31.3	29.0	28.6	30.2	30.4	1.971	0.441

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Body and Organ Weights (g) for Virgin Mice

TMT=37 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	Exposure Day 1 Wt (g)	Exposure Day 3 Wt (g)	Exposure Day 6 Wt (g)	Exposure Day 9 Wt (g)	Exposure Day 12 Wt (g)	Sacrifice Wt (g)	Liver Wt (g)	Kidney Wt (g)
102	31.2	29.0	30.2	.	.	.	.	.	.
136	32.4	30.9	31.6	28.7	30.1	29.9	30.9	1.687	0.415
149	27.6	26.6	27.2	25.3	.	.	.	.	.
165	28.8	27.7	27.7	26.9	.	.	.	.	.
222	29.8	29.4	28.3	25.6	.	.	.	.	.
241	29.4	28.3	27.9	26.2	.	.	.	.	.
274	32.2	32.9	31.9	29.8	.	.	.	.	.
277	28.6	29.4	28.1	25.0	27.9	28.3	29.1	2.003	0.462
286	26.5	29.0	28.4	27.0	.	.	.	.	.
352	31.0	29.2	30.6	26.0	.	.	.	.	.

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Body and Organ Weights (g) for Virgin Mice

TMT=75 mg/m3 Gallium Arsenide

MATNO	Pre-study Wt (g)	Exposure Day 1 Wt (g)	Exposure Day 3 Wt (g)	Exposure Day 6 Wt (g)	Exposure Day 9 Wt (g)	Exposure Day 12 Wt (g)	Sacrifice Wt (g)	Liver Wt (g)	Kidney Wt (g)
23	28.8	25.6	26.3	25.6	.	.	.	.	.
60	28.6	28.1	26.0	24.7	.	.	.	.	.
69	32.5	31.0	30.6	25.1	.	.	.	.	.
90	29.3	29.6	28.0	27.7	.	.	.	.	.
104	27.9	27.4	27.3	26.0	25.1	26.6	27.3	1.600	0.430
189	29.2	29.2	29.0	24.0	.	.	.	.	.
211	30.5	29.3	28.7	24.0	.	.	.	.	.
214	29.8	28.5	28.6	26.4	.	.	.	.	.
267	32.3	30.7	29.8	28.6	.	.	.	.	.
268	31.4	30.4	30.9	27.4	28.6	28.7	30.0	2.357	0.483

Reproductive Measures and Fetal Data

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

Code Sheet for Identification of Fetal Abnormalities

CLPA	Cleft Palate
DIUR	Dilated Ureter
EDEM	Edema
MAST	Misaligned Sternebrae
MIIN	Missing Innominate Artery
RBDE	Rib Defect
ROPB	Reduced Ossification Pelvis
ROPH	Reduced Ossification Phalanges
ROSK	Reduced Ossification Skull
ROST	Reduced Ossification Sternebrae
ROVE	Reduced Ossification Vertebrae
RPCA	Renal Pelvic Cavitation
SNRB	Supernumerary Ribs
STDE	Sternebral Defect

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

Ø mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
364	1	1	4.297	Ø.334	1	V	ROVE	SNRB			
364	2	2	Ø.ØØØ	Ø.ØØØ	.						
364	3	1	4.892	Ø.386	2	H					
364	4	1	4.461	Ø.336	2	V					
364	5	1	4.479	Ø.354	2	H	ROVE				
364	6	1	4.642	Ø.369	2	V					
364	7	1	3.733	Ø.252	1	H					
364	8	1	5.289	Ø.376	1	V					
364	9	1	3.960	Ø.331	2	H	ROVE				
364	10	1	4.462	Ø.371	2	V					
364	11	1	4.619	Ø.369	2	H					
364	12	1	4.801	Ø.413	1	V					
364	13	1	4.626	Ø.297	1	H	ROST	SNRB	RBDE	ROVE	
364	14	1	4.239	Ø.373	1	V	SNRB				
369	1	1	2.964	Ø.263	2	H					
369	2	1	3.383	Ø.321	1	V					
369	3	1	3.522	Ø.337	1	H					
369	4	1	3.392	Ø.325	1	V	ROST				
369	5	1	3.583	Ø.301	2	H					
369	6	1	3.476	Ø.354	1	V	DIUR	RPCA			
369	7	1	3.342	Ø.293	2	H					
369	8	1	3.807	Ø.424	1	V					
369	9	1	3.338	Ø.287	1	H					
369	10	1	3.258	Ø.303	2	V					
369	11	1	3.457	Ø.315	1	H	ROVE				
369	12	1	3.183	Ø.315	2	V					
369	13	1	3.788	Ø.368	2	H					
369	14	1	3.413	Ø.347	1	V	DIUR	RPCA	SNRB		
369	15	1	3.353	Ø.306	2	H	RBDE				
369	16	1	3.479	Ø.391	2	V					
369	17	1	3.573	Ø.273	2	H	RBDE				
372	1	4	Ø.ØØØ	Ø.ØØØ	.						
372	2	1	3.667	Ø.296	1	H					
372	3	4	Ø.ØØØ	Ø.ØØØ	.						
372	4	1	3.780	Ø.362	1	V					
372	5	1	3.763	Ø.326	2	H					
372	6	1	3.659	Ø.334	1	V					
372	7	1	4.082	Ø.357	1	H	ROVE				
372	8	1	4.130	Ø.411	1	V					
372	9	1	3.716	Ø.315	1	H					
372	10	1	3.751	Ø.340	1	V	ROSK				
372	11	2	Ø.ØØØ	Ø.ØØØ	.						
372	12	1	3.602	Ø.315	2	H					
372	13	1	3.615	Ø.337	1	V	ROSK				
372	14	1	3.591	Ø.322	2	H					
372	15	1	3.784	Ø.369	2	V	ROSK				
372	16	1	3.697	Ø.307	1	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

0 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
384	1	2	0.000	0.000	.						
384	2	1	3.310	0.291	1	H					
384	3	1	2.872	0.251	2	V	ROST				
384	4	1	3.257	0.251	2	H					
384	5	1	3.063	0.250	2	V					
384	6	1	3.181	0.250	2	H	ROST				
384	7	1	3.828	0.332	1	V					
384	8	1	3.821	0.310	1	H					
384	9	1	3.431	0.342	2	V					
384	10	1	3.595	0.331	2	H					
384	11	1	3.256	0.307	2	V					
384	12	1	3.754	0.299	1	H					
384	13	1	3.602	0.338	1	V					
384	14	1	3.472	0.308	2	H					
384	15	2	0.000	0.000	.						
384	16	4	0.000	0.000	.						
384	17	1	3.170	0.289	2	V					
391	1	1	3.388	0.288	2	H					
391	2	1	3.108	0.271	2	V	SNRB				
391	3	1	3.338	0.280	2	H					
391	4	1	3.575	0.340	1	V	SNRB				
391	5	1	3.695	0.299	2	H					
391	6	1	3.641	0.360	2	V					
391	7	1	4.030	0.323	1	H					
391	8	1	3.794	0.358	1	V	SNRB				
391	9	1	3.237	0.263	2	H					
391	10	1	3.311	0.314	2	V					
391	11	1	3.817	0.286	1	H					
391	12	1	3.964	0.337	2	V					
391	13	1	3.817	0.308	2	H					
391	14	1	3.528	0.332	2	V	ROSK				
391	15	1	1.916	0.116	2	H	ROST				
391	16	1	3.658	0.305	1	V	ROSK				
431	1	1	3.393	0.306	2	V					
431	2	1	3.484	0.276	1	H					
431	3	1	3.297	0.270	1	V					
431	4	1	3.299	0.254	2	H					
431	5	1	3.467	0.344	2	V					
431	6	1	3.448	0.271	2	H					
431	7	1	3.489	0.331	1	V					
431	8	1	3.612	0.293	1	H					
431	9	1	3.778	0.355	1	V					
431	10	1	3.525	0.293	1	H					
431	11	1	3.629	0.325	1	V					
431	12	1	3.655	0.285	1	H					
431	13	1	3.860	0.354	1	V					
431	14	1	3.652	0.308	1	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

---------- 0 mg/m3 Gallium Arsenide ----------

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
431	15	1	3.588	0.347	2	V					
431	16	1	3.820	0.313	1	H	SNRB				
431	17	1	3.473	0.341	2	V	SNRB				
431	18	1	3.761	0.320	2	H					
431	19	1	3.829	0.382	1	V					
431	20	1	3.684	0.314	2	H					
447	1	1	3.546	0.340	1	H					
447	2	1	3.418	0.319	1	V					
447	3	1	3.657	0.319	1	H					
447	4	1	3.571	0.315	2	V					
447	5	1	3.643	0.317	2	H					
447	6	1	3.892	0.359	1	V	ROVE				
447	7	1	3.690	0.316	2	H					
447	8	1	3.690	0.304	1	V					
447	9	1	3.656	0.295	1	H					
447	10	1	3.678	0.358	2	V					
447	11	1	3.526	0.330	2	H					
447	12	1	3.840	0.348	1	V	SNRB				
447	13	1	3.672	0.350	2	H					
447	14	1	3.738	0.328	1	V	ROVE				
447	15	1	3.831	0.337	1	H					
447	16	1	3.685	0.327	2	V					
447	17	1	3.415	0.310	2	H					
447	18	1	3.372	0.325	2	V					
465	1	1	3.311	0.298	2	V					
465	2	1	3.799	0.229	1	H	MSST				
465	3	1	3.778	0.384	2	V					
465	4	1	4.003	0.357	1	H	ROVE				
465	5	1	3.787	0.316	2	V					
465	6	1	3.870	0.320	2	H					
465	7	1	3.529	0.319	2	V	ROSK				
465	8	1	3.680	0.333	1	H					
465	9	1	3.667	0.296	2	V					
465	10	1	3.609	0.267	2	H					
465	11	1	3.745	0.353	1	V					
465	12	1	3.663	0.278	2	H					
465	13	2	0.000	0.000	.						
465	14	1	3.193	0.257	1	V	DIUR	ROPB			
465	15	1	4.052	0.347	1	H					
466	1	4	0.000	0.000	.						
466	2	1	3.724	0.303	1	H					
466	3	1	3.689	0.340	1	V					
466	4	1	3.928	0.283	1	H					
466	5	1	3.785	0.282	2	V					
466	6	1	3.828	0.305	1	H					
466	7	1	4.000	0.296	1	V	SNRB				
466	8	1	3.431	0.269	2	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: [illegible]at Fetal Data

---------- 0 mg/m3 Gallium Arsenide ----------

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
466	9	1	2.913	0.254	1	V	SNRB				
466	10	1	2.089	0.099	1	H	ROST	SNRB	ROPB		
466	11	1	3.647	0.327	1	V					
466	12	1	4.047	0.315	1	H					
466	13	1	3.124	0.245	2	V					
466	14	1	3.852	0.285	1	H					
466	15	1	3.849	0.384	1	V					
466	16	1	3.649	0.293	2	H					
466	17	1	3.802	0.340	2	V					
530	1	1	2.253	0.240	1	H	ROST	ROPB	ROPH		
530	2	1	3.836	0.389	1	V	ROVE				
530	3	1	3.764	0.337	1	H	ROVE				
530	4	4	0.000	0.000	.						
531	1	1	3.317	0.324	2	V					
531	2	1	3.147	0.161	2	H					
531	3	1	3.476	0.222	2	V					
531	4	1	3.167	0.200	2	H					
531	5	1	3.898	0.268	1	V	DIUR	SNRB			
531	6	1	3.672	0.225	1	H	ROVE				
531	7	1	3.599	0.188	1	V	DIUR	RPCA			
531	8	1	3.661	0.251	2	H					
531	9	1	3.820	0.268	2	V	SNRB				
531	10	1	3.064	0.184	1	H					
531	11	1	3.381	0.232	1	V	DIUR	RPCA	ROVE	SNRB	
531	12	2	0.000	0.000	.						
531	13	1	3.828	0.236	1	H	ROVE				
531	14	1	3.478	0.290	2	V	DIUR	ROVE			
531	15	1	3.357	0.227	2	H					
531	16	1	3.743	0.271	2	V					
531	17	1	3.500	0.251	2	H					
536	1	1	3.498	0.315	1	V	ROSK				
536	2	1	3.759	0.330	1	H					
536	3	1	3.720	0.338	1	V					
536	4	1	3.498	0.309	2	H					
536	5	1	3.756	0.335	2	V					
536	6	1	3.835	0.305	1	H					
536	7	1	3.846	0.332	1	V					
536	8	1	3.827	0.299	1	H					
536	9	1	3.775	0.337	1	V	ROSK				
536	10	1	3.277	0.285	2	H					
536	11	1	3.663	0.309	1	V					
536	12	1	3.686	0.301	1	H					
536	13	1	3.572	0.269	1	V	ROSK				
536	14	1	3.364	0.293	1	H					
536	15	1	3.776	0.383	2	V					
536	16	1	3.888	0.323	1	H					
536	17	1	3.717	0.362	1	V	ROSK				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

---------- Ø mg/m3 Gallium Arsenide ----------

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
542	1	1	3.083	Ø.319	2	H					
542	2	2	Ø.ØØØ	Ø.ØØØ	.						
542	3	1	3.377	Ø.257	1	V					
542	4	1	3.228	Ø.323	2	H					
542	5	1	3.247	Ø.267	2	V	RBDE	ROVE			
542	6	1	3.290	Ø.270	2	H	ROVE				
542	7	1	3.242	Ø.279	2	V					
542	8	1	3.344	Ø.269	2	H	ROVE				
542	9	1	3.334	Ø.304	1	V	ROVE				
542	10	1	3.097	Ø.303	2	H	ROVE				
542	11	1	3.307	Ø.313	2	V	ROVE				
542	12	1	3.254	Ø.299	2	H	ROVE				
542	13	1	3.294	Ø.307	1	V	ROSK				
542	14	1	3.251	Ø.307	2	H	ROVE				
542	15	1	3.445	Ø.276	2	V	ROSK	ROVE			
542	16	1	3.494	Ø.261	2	H	ROVE				
542	17	1	3.337	Ø.339	2	V					
542	18	1	1.862	Ø.297	2	H	ROVE				
542	19	1	3.451	Ø.135	2	V	ROSK	ROST	ROPB	ROPH	
560	1	1	3.243	Ø.268	1	V					
560	2	1	3.637	Ø.309	1	H					
560	3	1	3.627	Ø.343	2	V					
560	4	1	3.746	Ø.335	1	H					
560	5	1	3.731	Ø.329	1	V					
560	6	1	3.458	Ø.279	2	H	ROST	ROVE			
560	7	1	3.538	Ø.353	2	V					
560	8	1	3.604	Ø.338	2	H	ROVE				
560	9	1	3.708	Ø.376	1	V					
560	10	1	3.560	Ø.296	2	H	ROVE				
560	11	1	3.462	Ø.340	2	V					
560	12	1	3.729	Ø.318	2	H					
560	13	1	3.823	Ø.402	1	V	ROVE				
560	14	1	3.327	Ø.285	2	H					
560	15	1	3.380	Ø.328	2	V					
560	16	1	3.679	Ø.305	1	H					
560	17	1	3.945	Ø.365	1	V					
606	1	1	3.928	Ø.382	2	V					
606	2	1	3.689	Ø.335	1	H					
606	3	1	3.355	Ø.289	2	V	ROVE				
606	4	1	4.013	Ø.341	1	H					
606	5	1	3.386	Ø.295	2	V					
606	6	1	3.879	Ø.369	2	H	SNRB				
606	7	1	3.919	Ø.355	2	V					
606	8	1	3.961	Ø.343	2	H	SNRB				
606	9	4	Ø.ØØØ	Ø.ØØØ	.						
606	10	4	Ø.ØØØ	Ø.ØØØ	.						
618	1	1	3.389	Ø.345	2	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

---------- Ø mg/m3 Gallium Arsenide ----------

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
618	2	1	3.743	Ø.283	1	H					
618	3	1	3.714	Ø.370	2	V					
618	4	1	3.982	Ø.345	1	H					
618	5	1	3.696	Ø.341	2	V	SNRB				
618	6	1	3.516	Ø.288	2	H	ROST	MAST			
618	7	1	3.561	Ø.348	2	V	ROST				
618	8	1	2.633	Ø.238	2	H	ROST				
618	9	1	3.626	Ø.348	1	V	ROST				
618	10	1	3.598	Ø.320	2	H					
618	11	1	3.838	Ø.354	2	V	DIUR				
618	12	2	Ø.000	Ø.000	.						
618	13	1	3.807	Ø.320	1	H	ROVE				
618	14	1	3.603	Ø.342	2	V	ROST	ROVE			
618	15	1	3.679	Ø.283	2	H	ROVE				
618	16	1	3.891	Ø.330	1	V	ROVE				
623	1	1	2.996	Ø.167	2	H					
623	2	1	3.193	Ø.178	2	V	ROVE				
623	3	1	3.487	Ø.252	2	H					
623	4	1	3.167	Ø.259	2	V	ROVE				
623	5	1	3.544	Ø.286	2	H	SNRB				
623	6	1	3.456	Ø.265	1	V	ROVE				
623	7	1	3.387	Ø.219	1	H					
623	8	1	3.398	Ø.191	2	V					
623	9	1	3.538	Ø.218	1	H	ROVE	SNRB			
623	10	1	2.355	Ø.128	1	V	ROST				
623	11	1	3.623	Ø.283	2	H	ROVE				
623	12	1	3.584	Ø.283	2	V					
623	13	1	3.829	Ø.304	2	H	ROVE				
623	14	1	3.608	Ø.246	1	V					
623	15	1	3.453	Ø.170	1	H					
623	16	1	3 [illegible]1	Ø.343	1	V	ROVE				
623	17	1	3 [illegible]8	Ø.267	2	H	ROVE				
624	1	4	Ø.000	Ø.000	.						
624	2	1	3.213	Ø.229	1	H					
624	3	1	3.276	Ø.291	2	V					
624	4	1	3.203	Ø.280	2	H					
624	5	1	3.471	Ø.272	1	V					
624	6	1	3.373	Ø.259	1	H					
624	7	1	3.575	Ø.278	1	V					
624	8	1	3.488	Ø.294	1	H	SNRB				
624	9	1	2.875	Ø.193	2	V					
624	10	1	3.551	Ø.264	1	H					
624	11	1	3.396	Ø.276	2	V					
624	12	1	3.218	Ø.231	2	H					
624	13	1	3.521	Ø.280	1	V	MAST				
624	14	4	Ø.000	Ø.000	.						
624	15	1	3.547	Ø.280	1	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

Ø mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
624	16	1	3.256	Ø.275	2	V					
624	17	1	3.427	Ø.298	2	H					
634	1	4	Ø.ØØØ	Ø.ØØØ	.						
634	2	1	3.299	Ø.291	2	H					
634	3	1	3.767	Ø.393	2	V					
634	4	1	4.Ø91	Ø.393	1	H	COST				
634	5	1	3.7Ø4	Ø.367	2	V					
634	6	1	3.348	Ø.283	2	H					
634	7	1	3.888	Ø.3Ø8	1	V	DIUR				
634	8	1	3.943	Ø.329	1	H					
634	9	1	3.7Ø2	Ø.336	2	V					
634	1Ø	1	3.447	Ø.29Ø	1	H					
634	11	1	4.153	Ø.357	1	V	DIUR				
634	12	1	3.718	Ø.325	1	H					
634	13	1	3.469	Ø.345	2	V					
634	14	1	3.949	Ø.326	1	H	ROVE	SNRB			
634	15	1	3.4Ø6	Ø.276	1	V	DIUR				
643	1	1	3.612	Ø.294	1	H					
643	2	1	3.98Ø	Ø.378	2	V					
643	3	1	3.9Ø6	Ø.3Ø6	2	H					
643	4	1	3.787	Ø.343	2	V	ROST				
643	5	1	4.177	Ø.34Ø	1	H					
643	6	2	Ø.ØØØ	Ø.ØØØ	.						
643	7	1	4.445	Ø.315	1	V	DIUR				
643	8	1	4.Ø31	Ø.353	1	H					
643	9	1	4.123	Ø.349	1	V					
643	1Ø	1	4.Ø51	Ø.336	2	H	ROVE				
643	11	1	3.92Ø	Ø.29Ø	2	V					
643	12	1	4.196	Ø.265	1	H					
643	13	1	3.59Ø	Ø.263	1	V					
653	1	1	3.872	Ø.3Ø5	1	H	ROVE				
653	2	1	4.375	Ø.387	1	V	SNRB				
653	3	2	Ø.ØØØ	Ø.ØØØ	.						
653	4	1	4.235	Ø.343	1	H	SNRB				
653	5	1	3.549	Ø.326	1	V					
653	6	1	3.6Ø9	Ø.263	2	H					
653	7	1	4.ØØ1	Ø.369	2	V					
653	8	1	3.825	Ø.298	2	H					
653	9	1	4.246	Ø.438	2	V					
653	1Ø	1	3.893	Ø.319	2	H					
653	11	1	3.6Ø2	Ø.381	2	V	ROVE	SNRB			
653	12	1	3.778	Ø.3Ø2	2	H					
653	13	1	3.774	Ø.4Ø7	2	V					
653	14	1	3.938	Ø.418	2	H	SNRB				
653	15	1	3.965	Ø.347	1	V	SNRB	DIUR	RPCA		
654	1	1	3.Ø34	Ø.248	1	V	ROST				
654	2	1	2.963	Ø.261	2	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

---------- Ø mg/m3 Gallium Arsenide ----------

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
654	3	1	3.603	Ø.355	2	V	ROSK	ROVE			
654	4	1	3.436	Ø.263	1	H					
654	5	1	3.671	Ø.358	2	V	ROSK				
654	6	1	3.964	Ø.279	1	H					
654	7	1	3.486	Ø.301	2	V	ROSK	ROVE			
654	8	1	3.638	Ø.271	1	H					
654	9	1	3.403	Ø.298	1	V					
654	10	1	4.014	Ø.304	1	H					
654	11	1	3.647	Ø.310	1	V	ROSK				
654	12	1	3.008	Ø.258	2	H					
654	13	1	3.925	Ø.325	1	V					
654	14	1	3.758	Ø.304	2	H					
654	15	1	3.758	Ø.328	2	V					
654	16	1	3.879	Ø.316	1	H					
654	17	1	4.180	Ø.395	1	V					
659	1	1	3.379	Ø.279	1	V	ROST				
659	2	1	3.631	Ø.281	2	H					
659	3	1	4.054	Ø.334	2	V					
659	4	1	3.415	Ø.273	2	H					
659	5	1	3.661	Ø.570	1	V					
659	6	1	3.586	Ø.256	2	H					
659	7	4	Ø.ØØØ	Ø.ØØØ	.						
659	8	1	3.782	Ø.277	1	V					
659	9	1	4.044	Ø.345	1	H					
659	10	1	3.830	Ø.350	1	V	SNRB				
659	11	1	3.718	Ø.277	2	H					
659	12	1	3.715	Ø.273	1	V					
659	13	1	3.837	Ø.279	1	H					
659	14	1	3.932	Ø.325	1	V	ROVE	ROPB			
689	1	1	3.442	Ø.269	1	H	ROST				
689	2	1	3.459	Ø.276	2	V	ROST				
689	3	1	3.663	Ø.287	2	H					
689	4	1	4.186	Ø.325	1	V					
689	5	1	4.187	Ø.325	1	H					
689	6	1	4.060	Ø.315	1	V					
689	7	1	3.630	Ø.251	1	H					
689	8	1	3.821	Ø.324	2	V	ROST				
689	9	1	3.695	Ø.280	2	H					
689	10	1	3.588	Ø.286	1	V					
689	11	1	3.568	Ø.283	1	H					
689	12	1	3.803	Ø.316	1	V					
689	13	1	3.267	Ø.230	2	H					
689	14	1	3.748	Ø.320	2	V					
689	15	1	3.855	Ø.301	1	H					
689	16	1	3.942	Ø.359	2	V					
689	17	1	3.756	Ø.304	2	H	ROVE				
689	18	1	3.650	Ø.348	2	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

---------- Ø mg/m3 Gallium Arsenide ----------

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
707	1	1	3.254	Ø.309	1	H					
707	2	1	3.319	Ø.365	2	V					
707	3	1	3.699	Ø.324	1	H	ROVE				
707	4	1	3.477	Ø.400	1	V					
707	5	1	3.474	Ø.320	2	H	ROVE				
707	6	1	3.706	Ø.395	1	V	ROVE				
707	7	1	3.655	Ø.286	2	H					
707	8	1	3.572	Ø.296	1	H					
707	9	1	3.422	Ø.284	2	H	ROVE				
707	10	1	3.923	Ø.414	1	V	ROVE	SNRB			
707	11	1	3.550	Ø.341	1	H	ROVE				
707	12	1	3.547	Ø.350	1	V					
707	13	1	3.442	Ø.341	1	H	ROST	ROVE	ROPB	ROPH	

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
380	1	1	3.218	0.264	2	H					
380	2	2	0.000	0.000	.						
380	3	1	3.396	0.319	1	V	ROST	SNRB			
380	4	1	3.327	0.256	1	H	ROST	ROVE			
380	5	1	3.503	0.385	2	V					
380	6	1	3.869	0.321	2	H	ROVE				
380	7	1	4.008	0.368	1	V	DIUR	ROVE			
380	8	1	3.278	0.266	2	H	ROST				
380	9	1	3.500	0.326	2	V	SNRB				
380	10	1	3.559	0.273	2	H					
380	11	1	3.598	0.320	1	V	ROVE				
380	12	1	3.212	0.249	2	H					
380	13	1	3.387	0.275	2	V	SNRB				
380	14	1	3.288	0.272	2	H	ROST				
380	15	1	3.280	0.286	2	V					
380	16	1	3.345	0.273	2	H	ROST				
380	17	1	3.732	0.326	1	V	SNRB				
382	1	1	3.657	0.295	2	V	DIUR	ROVE			
382	2	1	3.639	0.290	1	H	ROVE				
382	3	1	3.787	0.369	1	V					
382	4	1	3.719	0.289	1	H	ROVE				
382	5	1	3.264	0.297	2	V					
382	6	1	3.458	0.278	2	H	ROVE				
382	7	1	3.199	0.271	1	V					
382	8	1	3.215	0.252	1	H	ROVE				
382	9	1	3.486	0.318	2	V					
382	10	1	3.472	0.285	1	H					
382	11	1	3.230	0.276	1	V	DIUR				
382	12	1	3.663	0.293	2	H					
382	13	1	3.856	0.317	1	V					
382	14	1	3.311	0.271	2	H					
382	15	1	3.782	0.338	1	V					
382	16	1	3.550	0.305	2	H					
382	17	1	3.831	0.372	1	V					
438	1	1	3.227	0.300	2	V	ROVE				
438	2	1	3.162	0.273	2	H	ROVE				
438	3	1	3.134	0.316	1	V					
438	4	1	3.545	0.282	1	H	ROVE				
438	5	1	3.630	0.293	1	V	SNRB				
438	6	1	3.782	0.319	1	H					
438	7	1	3.350	0.308	2	V					
438	8	1	3.441	0.278	2	H					
438	9	1	3.761	0.340	1	V					
438	10	1	2.917	0.207	2	H	ROST	ROVE			
438	11	1	3.623	0.368	2	V	MAST	ROVE	SNRB		
438	12	1	3.131	0.260	2	H					
438	13	1	4.024	0.418	1	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
438	14	1	3.823	0.335	1	H					
443	1	4	0.000	0.000	.						
443	2	1	3.264	0.295	1	H					
443	3	1	3.039	0.292	1	V					
443	4	1	3.141	0.267	1	H	ROVE				
443	5	1	3.139	0.296	2	V	ROVE				
443	6	1	3.117	0.271	2	H	ROVE				
443	7	1	3.004	0.272	1	V	MAST				
443	8	1	3.114	0.310	2	H					
443	9	1	2.898	0.266	1	V					
443	10	1	3.058	0.280	1	H	ROVE				
443	11	1	3.492	0.312	1	V					
443	12	1	2.882	0.254	2	H	ROVE				
443	13	1	3.086	0.257	2	V					
443	14	1	3.106	0.273	1	H					
443	15	1	2.913	0.233	2	V	ROVE				
443	16	1	2.811	0.229	2	H					
480	1	1	3.327	0.306	1	V	ROPB				
480	2	1	3.587	0.322	2	H					
480	3	1	3.898	0.405	1	V	ROSK				
480	4	1	1.788	0.132	2	H	ROST	RBDE	ROPH	ROPB	
480	5	1	3.990	0.340	1	V					
480	6	1	3.966	0.338	1	H					
480	7	1	3.771	0.360	2	V					
480	8	2	0.000	0.000	.						
480	9	1	3.437	0.282	2	H					
480	10	1	3.508	0.365	2	V					
480	11	1	3.578	0.281	1	H					
480	12	1	3.518	0.331	1	V					
480	13	1	.	0.282	2	H					
480	14	1	3.582	0.262	1	V					
480	15	1	3.796	0.352	1	H					
495	1	1	3.926	0.314	1	H					
495	2	1	3.935	0.374	2	V					
495	3	1	3.892	0.289	1	H					
495	4	1	4.050	0.365	1	V	DIUR				
495	5	1	3.540	0.273	1	H					
495	6	1	4.067	0.318	1	V	DIUR	RPCA			
520	1	1	2.107	0.280	2	H	ROST	ROPB	ROPH		
520	2	1	2.791	0.191	2	V	ROSK	ROPB			
520	3	1	2.990	0.218	1	H	ROPB				
520	4	1	3.216	0.233	1	V					
520	5	1	3.277	0.244	1	H					
520	6	1	3.233	0.228	1	V	ROPB				
520	7	1	3.343	0.247	1	H	ROST				
520	8	1	3.416	0.218	1	V					
520	9	1	3.266	0.247	1	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
520	10	1	3.446	0.218	2	V					
520	11	1	3.355	0.296	2	H					
520	12	1	3.661	0.243	2	V					
562	1	1	3.494	0.281	2	H					
562	2	1	3.476	0.301	2	V					
562	3	1	3.682	0.287	1	H					
562	4	1	3.623	0.307	2	V					
562	5	1	3.408	0.264	1	H	ROVE				
562	6	1	3.736	0.317	1	V					
562	7	1	3.746	0.279	1	H					
562	8	1	3.691	0.307	2	V					
562	9	1	3.557	0.246	2	H					
562	10	1	3.039	0.214	1	V					
562	11	1	3.599	0.265	1	H	SNRB				
562	12	1	3.243	0.261	2	V					
562	13	1	3.505	0.330	1	H					
562	14	1	3.780	0.271	1	V					
562	15	1	3.423	0.291	1	H	SNRB				
562	16	1	3.389	0.261	2	V	ROVE				
562	17	1	3.432	0.258	2	H	MSST				
562	18	1	3.422	0.276	2	V	ROVE				
562	19	1	3.681	0.286	1	H					
583	1	1	3.131	0.248	2	H					
583	2	1	2.865	0.235	2	V					
583	3	1	3.302	0.258	2	H					
583	4	1	3.358	0.325	2	V					
583	5	1	3.221	0.266	1	H					
583	6	1	2.953	0.219	1	V	ROST				
583	7	1	3.339	0.304	2	H					
583	8	1	2.830	0.236	2	V	ROST	SNRB			
583	9	1	3.279	0.291	2	H					
583	10	1	2.899	0.255	1	V					
583	11	1	3.067	0.255	2	H	ROST				
583	12	1	3.305	0.326	1	V	ROST				
583	13	1	3.172	0.248	2	H	ROST				
583	14	1	2.994	0.259	1	V	ROPB				
583	15	1	3.374	0.267	2	H					
583	16	1	3.106	0.257	2	V					
597	1	1	3.514	0.314	2	H	ROST				
597	2	1	3.577	0.332	1	V	ROST				
597	3	1	3.431	0.304	1	H	ROST	SNRB			
597	4	1	3.765	0.364	1	V					
597	5	1	3.608	0.311	2	H	ROST	SNRB			
597	6	1	3.702	0.336	1	V					
597	7	1	3.689	0.307	1	H	ROST				
597	8	1	3.126	0.308	2	V	ROST				
597	9	1	3.190	0.270	1	H	ROST	ROVE			

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
597	10	1	3.230	0.294	2	V	ROST				
597	11	1	3.243	0.267	1	H	ROST	SNRB			
597	12	1	3.387	0.300	1	V					
597	13	1	3.416	0.284	2	H	ROST				
597	14	1	3.271	0.315	2	V	ROVE				
597	15	1	3.388	0.291	2	H					
597	16	1	3.231	0.304	2	V	ROST				
597	17	1	3.485	0.274	1	H	ROST				
597	18	1	3.221	0.323	1	V	ROSK	ROST			
597	19	1	3.450	0.315	2	H					
602	1	1	3.106	0.278	1	V	ROSK	ROST	ROVE		
602	2	1	3.525	0.323	1	H					
602	3	1	4.494	0.429	1	V	DIUR	RPCA	ROSK	ROST	
610	1	1	3.547	0.322	2	H	ROVE				
610	2	1	3.370	0.266	1	V	DIUR	ROST			
610	3	1	3.868	0.280	1	H					
610	4	1	3.692	0.273	2	V					
610	5	1	4.071	0.330	1	H	ROVE				
610	6	1	3.991	0.322	1	V	ROSK				
610	7	1	4.055	0.286	2	H					
610	8	1	4.288	0.363	1	V					
610	9	1	3.210	0.243	2	H	ROST				
610	10	1	3.837	0.333	1	V	ROVE				
610	11	1	3.645	0.312	2	H					
610	12	1	3.887	0.298	1	V	ROST	MAST			
610	13	1	3.215	0.236	2	H	ROVE				
610	14	1	3.749	0.321	1	V	ROVE				
610	15	1	3.621	0.317	1	H					
610	16	1	4.011	0.365	1	V	SNRB				
610	17	1	4.129	0.363	1	H					
614	1	4	0.000	0.000	.						
614	2	1	4.138	0.333	1	H					
614	3	1	3.266	0.304	1	V					
614	4	1	3.310	0.273	1	H					
614	5	1	2.971	0.293	2	V					
614	6	2	0.000	0.000	.						
614	7	1	4.362	0.424	1	H	ROVE				
614	8	1	4.705	0.458	1	V	ROVE				
614	9	1	4.331	0.392	2	H	ROVE				
614	10	1	2.967	0.280	1	V	ROST	MAST	ROVE		
614	11	1	4.175	0.271	2	H	ROVE	SNRB			
614	12	1	3.495	0.308	2	V	ROVE				
614	13	1	3.288	0.393	2	H	ROST	MAST	ROVE		
614	14	1	3.379	0.279	1	V	ROVE				
614	15	1	4.270	0.319	2	H	MAST	ROVE			
614	16	1	4.405	0.435	2	V	ROVE				
614	17	1	3.765	0.435	2	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
614	18	1	4.412	0.428	2	V	MAST	ROVE			
615	1	1	3.705	0.244	2	V					
616	2	1	3.672	0.209	2	H	ROST				
616	3	1	3.807	0.274	2	V	ROST				
616	4	1	3.627	0.199	2	H					
616	5	1	3.530	0.238	1	V					
616	6	1	3.669	0.219	2	H					
616	7	1	3.434	0.220	1	V					
616	8	1	3.768	0.231	1	H					
616	9	1	3.581	0.241	2	V					
616	10	1	2.854	0.111	2	H	ROST				
616	11	1	3.345	0.227	2	V					
616	12	1	3.481	0.218	2	H					
616	13	1	3.514	0.276	1	V					
616	14	1	3.915	0.259	1	H					
616	15	1	3.664	0.230	1	V					
616	16	1	3.465	0.274	2	H	ROST				
616	17	1	3.788	0.266	1	V	ROSK				
616	18	1	3.716	0.298	1	H	ROST				
629	1	1	3.500	0.278	2	H					
629	2	1	3.636	0.303	1	V					
629	3	1	3.318	0.249	2	H					
629	4	1	3.723	0.297	1	V					
629	5	1	3.163	0.239	1	H					
629	6	1	2.902	0.231	1	V					
629	7	1	2.966	0.260	2	H					
629	8	1	3.487	0.283	1	V					
629	9	1	3.055	0.238	1	H					
629	10	1	3.269	0.257	1	V					
629	11	1	3.063	0.248	1	H					
629	12	1	3.195	0.000	2	V					
629	13	1	3.098	0.190	2	H					
629	14	1	3.480	0.303	1	V					
629	15	1	3.665	0.294	1	H					
629	16	1	3.689	0.332	1	V	DIUR				
635	1	1	3.808	0.293	1	H					
635	2	1	4.091	0.345	1	V					
635	3	1	4.207	0.324	1	H					
635	4	1	3.762	0.329	1	V					
635	5	1	3.595	0.291	2	H					
635	6	1	3.431	0.250	2	V					
635	7	1	3.896	0.318	1	H					
635	8	1	4.031	0.329	1	V					
635	9	1	4.350	0.351	1	H	SNRB				
635	10	1	3.803	0.368	2	V	DIUR				
635	11	1	3.910	0.298	2	H					
635	12	1	4.151	0.363	1	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
635	13	1	3.805	0.329	2	H					
635	14	1	4.219	0.419	2	V					
635	15	1	3.739	0.298	2	H					
635	16	1	3.932	0.325	1	V					
645	1	1	2.837	0.282	1	H	ROST				
645	2	1	3.038	0.295	1	V					
645	3	1	3.268	0.310	2	H					
645	4	1	3.244	0.297	2	V	ROST				
645	5	1	3.444	0.322	1	H					
645	6	1	3.914	0.344	1	V					
645	7	1	3.464	0.320	2	H					
645	8	1	3.639	0.378	1	V					
645	9	1	3.370	0.302	1	H					
645	10	1	3.080	0.301	2	V					
645	11	1	3.179	0.262	2	H					
645	12	1	3.053	0.292	2	V					
645	13	1	3.464	0.309	1	H					
645	14	4	0.000	0.000	.						
645	15	1	3.309	0.314	2	V	ROVE				
645	16	1	3.279	0.291	2	H					
649	1	1	3.744	0.299	1	H	ROST				
649	2	1	3.726	0.342	1	V	ROSK				
649	3	1	3.416	0.247	2	H					
649	4	1	3.889	0.321	1	V					
649	5	1	3.712	0.284	1	H					
649	6	1	3.770	0.356	2	V					
649	7	1	3.576	0.285	2	H					
649	8	1	3.383	0.300	2	V	ROVE				
649	9	1	3.401	0.263	2	H	ROVE	SNRB			
649	10	1	3.820	0.347	1	V					
649	11	1	2.483	0.173	2	H	ROST				
649	12	1	3.502	0.347	2	V	SNRB				
649	13	1	3.400	0.288	2	H					
649	14	1	3.348	0.278	2	V					
649	15	1	3.240	0.312	2	H	ROST				
649	16	1	3.676	0.234	2	V	ROSK	SNRB			
649	17	1	3.744	0.316	1	H					
649	18	2	0.000	0.000	.						
656	1	1	3.286	0.259	1	H	ROST				
656	2	1	3.646	0.332	1	V	ROSK	ROVE			
656	3	1	3.407	0.259	1	H	ROVE				
656	4	1	3.633	0.307	1	V	ROSK				
656	5	1	3.733	0.308	1	H	ROVE				
656	6	1	3.266	0.271	2	V	ROSK	ROVE			
656	7	1	3.569	0.286	1	H	ROVE				
656	8	1	3.631	0.336	1	V	ROVE				
656	9	1	3.293	0.241	2	H	ROST				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
656	10	1	3.168	0.296	2	V	ROST				
656	11	1	3.002	0.235	2	H	ROST	MAST	ROVE		
656	12	1	3.269	0.283	2	V	ROVE				
656	13	4	0.000	0.000	.						
656	14	1	3.122	0.248	2	H	ROVE				
656	15	1	3.547	0.333	1	V					
656	16	1	3.244	0.265	2	H	ROST	ROVE			
656	17	1	3.409	0.271	2	V	ROVE				
656	18	1	2.919	0.252	2	H	ROST	ROVE			
656	19	1	3.427	0.314	2	V	ROST	ROVE			
672	1	1	3.775	0.371	1	V	ROVE				
672	2	1	3.612	0.363	2	H					
672	3	1	3.758	0.373	1	V					
672	4	2	0.000	0.000	.						
672	5	1	3.859	0.346	1	H	ROVE				
672	6	1	3.507	0.332	2	V					
672	7	1	3.613	0.329	2	H	ROVE				
672	8	1	3.747	0.387	2	V	ROVE				
672	9	1	3.368	0.295	2	H					
672	10	1	3.984	0.396	1	V					
672	11	1	3.818	0.383	2	H	ROVE				
672	12	1	4.061	0.367	2	V	ROVE	SNRB			
672	13	1	3.943	0.370	1	H	ROVE				
672	14	1	4.017	0.391	1	V	MAST	ROVE			
677	1	1	3.022	0.275	1	V					
677	2	1	3.147	0.262	1	H					
677	3	1	3.062	0.284	2	V					
677	4	1	3.707	0.319	1	H					
677	5	1	3.437	0.327	2	V					
677	6	1	3.578	0.310	1	H					
677	7	1	3.460	0.334	1	V					
677	8	1	3.553	0.312	1	H					
677	9	1	3.049	0.281	2	V	ROST	MAST	ROVE		
677	10	1	3.184	0.262	1	H					
677	11	1	3.275	0.316	2	V					
677	12	1	3.058	0.281	2	H					
677	13	1	2.979	0.256	2	V					
677	14	1	3.353	0.285	1	H	ROVE				
677	15	1	3.232	0.296	2	V					
679	1	1	3.293	0.305	1	H					
679	2	1	3.566	0.309	1	V	ROST				
679	3	1	3.687	0.352	2	H					
679	4	1	3.532	0.318	2	V	ROST				
679	5	1	3.424	0.282	1	H					
679	6	1	3.599	0.323	1	V					
679	7	1	3.651	0.325	2	H					
679	8	1	3.565	0.329	1	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
679	9	1	3.621	0.303	1	H					
679	10	1	3.527	0.318	2	V	ROVE				
679	11	1	3.498	0.261	1	H					
679	12	2	0.000	0.000	.						
679	13	1	3.779	0.327	1	V					
679	14	2	0.000	0.000	.						
679	15	1	3.561	0.301	1	H	ROST				
679	16	1	3.573	0.322	1	V					
684	1	1	3.132	0.244	2	V					
684	2	1	3.628	0.298	1	H	ROVE				
684	3	1	3.986	0.255	1	V	DIUR				
684	4	1	3.792	0.211	1	H	ROVE				
684	5	1	3.510	0.258	1	V					
684	6	1	3.685	0.299	2	H	COST				
684	7	1	3.712	0.236	2	V					
684	8	1	3.465	0.239	1	H					
684	9	1	3.640	0.310	2	V	ROVE				
684	10	1	3.786	0.273	1	H					
684	11	1	3.437	0.251	2	V	ROVE				
684	12	1	3.805	0.251	1	H					
684	13	1	3.238	0.252	1	V	ROVE	SNRB			
684	14	1	3.492	0.262	2	H					
684	15	1	3.548	0.273	1	V	ROVE				
684	16	1	3.659	0.220	2	H					
684	17	1	3.150	0.241	2	V	ROVE				
684	18	1	3.544	0.312	1	H					
694	1	2	0.000	0.000	.						
694	2	1	3.528	0.287	1	H	ROVE				
694	3	1	3.558	0.343	2	V					
694	4	1	3.647	0.254	2	H	CLPA	ROVE			
694	5	2	0.000	0.000	.						
694	6	1	3.833	0.343	1	V					
694	7	1	3.706	0.279	2	H					
694	8	1	3.393	0.297	1	V					
694	9	1	3.613	0.262	1	H	SNRB				
694	10	1	3.521	0.298	1	V					
694	11	1	3.672	0.265	2	H	COST				
694	12	2	0.000	0.000	.						
694	13	1	3.700	0.271	1	V	DIUR				
694	14	1	3.737	0.300	2	H	ROVE				
694	15	1	3.441	0.263	2	V					
694	16	1	3.301	0.225	2	H					
697	1	2	0.000	0.000	.						
697	2	1	3.435	0.289	2	H					
697	3	1	3.778	0.318	1	V					
697	4	1	3.743	0.250	1	H	ROVE				
697	5	1	3.675	0.285	2	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
697	6	2	0.000	0.000	.						
697	7	1	3.825	0.307	1	H	ROVE				
697	8	1	3.864	0.294	2	V					
697	9	1	3.401	0.282	2	H					
697	10	1	3.810	0.270	1	V					
697	11	1	3.685	0.263	1	H					
697	12	1	3.699	0.323	1	V					
697	13	1	3.471	0.256	1	H					
697	14	1	3.706	0.304	1	V	ROVE				
697	15	1	3.476	0.314	1	H					
697	16	1	3.956	0.267	1	V	ROVE				
697	17	1	3.649	0.300	2	H					
706	1	1	3.146	0.294	1	H	ROST	ROPH			
706	2	1	3.476	0.347	1	V					
706	3	1	3.525	0.280	1	H					
706	4	1	3.382	0.255	2	V	ROSK	ROST			
706	5	1	3.120	0.277	2	H					
706	6	1	3.490	0.300	1	V					
706	7	1	3.462	0.292	2	H					
706	8	1	3.400	0.276	2	V					
706	9	1	3.700	0.330	1	H					
706	10	1	3.327	0.298	2	V	ROSK				
706	11	1	3.488	0.283	2	H	ROST				
706	12	1	3.199	0.309	2	V	ROSK	ROST			
706	13	1	3.413	0.296	2	H	ROVE				
706	14	1	3.625	0.311	1	V	ROSK				
706	15	1	3.631	0.303	1	H					
706	16	1	3.413	0.272	2	V	ROSK	SNRB			
706	17	1	3.547	0.268	1	H					
716	1	1	3.053	0.215	1	H	ROST	ROPB			
716	2	1	3.479	0.281	1	V	MAST				
716	3	1	3.333	0.256	2	H	ROVE				
716	4	1	3.538	0.298	1	V					
716	5	1	3.213	0.257	2	H					
716	6	1	3.743	0.320	1	V	SNRB				
716	7	1	3.616	0.287	1	H	ROVE				
716	8	1	3.477	0.306	2	V					
716	9	4	0.000	0.000	.						
716	10	1	3.422	0.294	1	H					
716	11	1	3.351	0.294	2	V	ROVE	ROPB			
716	12	1	3.230	0.239	2	H					
716	13	1	3.492	0.285	2	V	ROVE				
716	14	1	3.362	0.251	2	H	ROST	ROVE			
716	15	1	3.505	0.283	2	V					
716	16	1	2.838	0.207	2	H	ROST	ROVE			
716	17	1	3.330	0.299	2	V	ROVE				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
370	1	1	3.095	0.318	2	V					
370	2	1	3.501	0.352	1	H	ROST				
370	3	1	3.482	0.355	2	V					
370	4	1	3.557	0.361	2	H					
370	5	1	3.353	0.321	1	V	ROST				
370	6	1	3.486	0.330	1	H					
370	7	1	3.487	0.347	2	V					
370	8	1	3.556	0.335	1	H					
370	9	1	2.856	0.267	1	V	ROST				
370	10	1	3.468	0.355	2	H					
370	11	1	3.532	0.332	1	V	ROST				
370	12	1	3.359	0.299	2	H					
370	13	1	3.494	0.384	2	V					
370	14	1	3.768	0.373	1	H					
377	1	1	3.627	0.270	1	H	SNRB				
377	2	1	3.178	0.244	2	V					
377	3	1	3.579	0.261	2	H					
377	4	1	3.684	0.321	1	V					
377	5	1	3.504	0.245	2	H	ROST	ROVE			
377	6	1	3.312	0.277	2	V					
377	7	1	3.298	0.272	2	H	ROST				
377	8	1	3.662	0.331	1	V					
377	9	1	3.727	0.319	1	H	ROST	MAST			
377	10	1	3.512	0.317	1	V					
377	11	1	3.191	0.253	2	H	ROST				
377	12	1	3.582	0.338	2	V					
377	13	1	3.798	0.293	1	H					
377	14	1	3.502	0.308	1	V					
377	15	1	3.632	0.289	1	H	ROST				
381	1	1	2.893	0.198	2	H					
381	2	1	3.362	0.250	1	V					
381	3	1	3.543	0.285	1	H	ROVE				
381	4	1	3.413	0.274	2	V	ROVE				
381	5	1	3.640	0.252	1	H					
381	6	1	3.547	0.288	1	V					
381	7	1	3.410	0.236	1	H	ROVE				
381	8	1	2.574	0.177	1	V					
381	9	1	3.312	0.256	1	H					
381	10	1	3.417	0.289	2	V					
381	11	1	3.140	0.199	1	H					
381	12	4	0.000	0.000	.						
381	13	1	3.199	0.271	2	V					
381	14	4	0.000	0.000	.						
381	15	1	3.223	0.228	2	H					
381	16	1	3.328	0.242	1	V					
381	17	4	0.000	0.000	.						
381	18	1	3.434	0.287	2	H	ROVE				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
396	1	1	3.201	0.316	2	V					
396	2	1	3.369	0.354	2	H					
396	3	1	3.429	0.308	1	V					
396	4	2	0.000	0.000	.						
396	5	1	3.250	0.357	2	H					
396	6	1	3.388	0.314	2	V					
396	7	1	3.376	0.318	1	H					
396	8	1	3.250	0.339	2	V	ROVE				
396	9	1	3.364	0.314	1	H					
396	10	1	3.222	0.342	2	V					
396	11	1	3.438	0.305	1	H					
492	1	4	0.000	0.000	.						
492	2	1	2.951	0.252	2	H	ROST	ROVE			
492	3	1	3.333	0.353	1	V	ROST				
492	4	1	3.170	0.266	2	H	ROVE				
492	5	1	3.668	0.362	1	V					
492	6	1	3.706	0.317	1	H					
492	7	1	3.214	0.302	2	V	ROVE				
492	8	1	2.253	0.201	1	H	ROST	ROPB	ROPH		
492	9	1	3.376	0.347	1	V	ROST				
492	10	1	3.391	0.272	1	H					
492	11	1	3.257	0.287	2	V	ROPH				
492	12	1	3.152	0.311	2	H	ROST				
492	13	1	3.184	0.315	1	V	ROST				
492	14	1	3.474	0.308	1	H					
492	15	1	3.532	0.369	1	V					
492	16	1	3.182	0.285	2	H	ROST				
498	1	1	3.273	0.272	1	H	ROVE	ROPB			
498	2	1	3.965	0.350	1	V	SNRB				
498	3	1	2.869	0.216	1	H	ROST	ROVE	SNRB		
498	4	1	3.065	0.296	1	V	ROSK	ROST	ROVE	SNRB	ROPB
498	5	1	3.698	0.286	1	H					
498	6	1	3.584	0.340	2	V					
498	7	1	2.785	0.197	2	H	ROST	ROVE			
498	8	1	3.477	0.306	2	V	ROSK				
498	9	1	3.817	0.342	1	H	ROST				
498	10	1	3.521	0.291	1	V	ROST	SNRB			
498	11	1	3.976	0.334	1	H	ROST				
498	12	1	3.040	0.257	2	V	ROST	ROVE			
498	13	1	3.579	0.289	1	H	ROST	SNRB			
498	14	1	3.420	0.267	1	V	ROVE	SNRB			
498	15	2	0.000	0.000	.						
498	16	1	3.835	0.333	2	H					
498	17	1	3.195	0.282	2	V	ROST	ROVE	SNRB		
498	18	1	3.498	0.242	1	H	ROST				
525	1	1	3.572	0.337	1	H					
525	2	1	3.928	0.390	1	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
525	3	1	3.288	0.313	2	H					
525	4	1	4.028	0.388	1	V					
525	5	1	3.857	0.371	2	H					
525	6	1	3.783	0.345	1	V					
525	7	1	3.485	0.301	2	H					
525	8	2	0.000	0.000	.						
525	9	1	3.664	0.345	2	V					
525	10	1	3.948	0.348	1	H					
525	11	2	0.000	0.000	.						
525	12	1	4.222	0.440	1	V	DIUR				
525	13	1	3.931	0.337	2	H					
525	14	1	3.972	0.375	1	V					
525	15	1	4.321	0.408	1	H	ROST				
543	1	1	3.052	0.267	2	V	ROVE				
543	2	1	3.423	0.288	1	H	ROVE				
543	3	1	3.201	0.312	2	V	ROVE				
543	4	1	3.354	0.293	1	H					
543	5	1	3.361	0.308	1	V					
543	6	1	2.913	0.246	1	H	ROST				
543	7	1	3.307	0.314	1	V	ROVE				
543	8	1	3.277	0.287	1	H	ROVE				
543	9	1	3.381	0.315	1	V	ROVE				
543	10	1	3.511	0.311	1	H	ROVE				
543	11	1	3.098	0.291	2	V	ROVE				
543	12	1	3.192	0.277	2	H					
543	13	1	2.969	0.271	2	V	ROVE				
543	14	1	3.140	0.270	2	H	ROVE				
543	15	1	3.049	0.303	1	V	ROVE				
543	16	1	3.441	0.298	1	H	ROVE				
543	17	1	3.318	0.258	1	V					
558	1	1	3.544	0.275	2	H	ROVE				
558	2	1	3.445	0.346	2	V					
558	3	1	3.985	0.323	2	H					
558	4	1	3.920	0.378	1	V					
558	5	1	3.485	0.297	2	H	ROST				
558	6	2	0.000	0.000	.						
558	7	1	4.039	0.371	1	V					
558	8	1	3.943	0.321	1	H	ROST				
558	9	1	3.550	0.303	1	V					
558	10	1	3.431	0.254	2	H	ROST				
558	11	1	3.527	0.329	2	V	ROVE				
558	12	1	3.600	0.313	2	H					
558	13	1	2.702	0.204	2	V	ROST	MAST	ROVE		
558	14	1	3.321	0.278	2	H					
558	15	1	3.593	0.330	1	V	ROVE				
558	16	1	3.652	0.277	1	H	ROVE				
558	17	1	3.256	0.282	2	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
571	1	1	2.139	0.140	2	V	ROST	ROPB	ROPH		
571	2	1	3.432	0.230	1	H	SNRB				
571	3	1	3.376	0.257	1	V	ROVE				
571	4	1	3.406	0.239	2	H					
571	5	1	3.704	0.247	1	V					
571	6	1	3.153	0.204	2	H					
571	7	1	3.483	0.236	1	V	ROVE				
571	8	1	3.555	0.245	2	H					
571	9	1	3.110	0.274	2	V	ROST				
571	10	1	3.720	0.261	1	H					
571	11	1	3.322	0.299	1	V					
571	12	1	3.823	0.292	2	H	SNRB				
571	13	1	3.344	0.226	2	V	ROVE				
571	14	1	3.491	0.219	1	H					
571	15	1	3.615	0.336	2	V					
571	16	1	3.643	0.237	1	H					
571	17	1	3.788	0.277	1	V					
571	18	1	3.482	0.234	2	H					
575	1	1	3.658	0.344	1	V					
575	2	1	3.453	0.289	1	H					
575	3	2	0.000	0.000	.						
575	4	1	3.916	0.337	1	V					
575	5	1	3.798	0.315	1	H	ROVE	SNRB			
575	6	1	3.388	0.311	2	V	ROST	ROVE	SNRB		
575	7	1	3.456	0.293	1	H	ROST	ROVE			
575	8	1	3.601	0.294	1	V					
575	9	1	3.638	0.284	1	H	ROVE				
575	10	1	3.420	0.324	2	V	ROVE				
575	11	1	3.705	0.329	1	H	ROVE				
575	12	1	3.651	0.368	2	V	ROVE				
575	13	1	3.186	0.249	2	H	ROST				
575	14	1	3.470	0.291	2	V	ROST				
575	15	1	3.509	0.263	1	H	MAST				
575	16	1	3.557	0.351	1	V	ROST				
575	17	1	3.907	0.330	1	H					
587	1	1	3.565	0.416	1	V					
587	2	1	3.263	0.313	2	H					
587	3	1	3.620	0.316	1	V	ROST	ROVE			
587	4	4	0.000	0.000	.						
587	5	1	2.980	0.284	2	H	ROVE				
587	6	1	2.990	0.242	2	V					
587	7	1	3.341	0.335	2	H					
587	8	1	3.589	0.282	1	V	ROST				
587	9	1	3.269	0.277	1	H	ROST				
587	10	1	3.505	0.290	1	V					
587	11	1	3.458	0.285	1	H					
587	12	1	3.235	0.282	1	V	SNRB				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
587	13	1	3.200	0.265	2	H	ROST				
587	14	1	3.452	0.294	1	V	ROST				
587	15	1	3.380	0.285	1	H	ROST				
587	16	1	3.699	0.272	1	V	ROST				
591	1	1	3.162	0.201	2	H					
591	2	1	3.493	0.291	1	V	DIUR				
591	3	1	3.153	0.240	1	H	ROVE				
591	4	1	3.162	0.276	2	V					
591	5	1	3.395	0.269	2	H	ROVE				
591	6	1	3.170	0.306	2	V					
591	7	1	3.389	0.285	2	H					
591	8	1	3.039	0.278	2	V					
591	9	1	3.306	0.260	1	H					
591	10	1	3.582	0.304	1	V	DIUR	MSST			
591	11	2	0.000	0.000	.						
591	12	1	3.170	0.233	2	H					
591	13	1	3.523	0.273	1	V					
591	14	1	3.459	0.289	1	H					
591	15	1	3.110	0.265	1	V	ROST				
593	1	1	3.555	0.299	1	H	ROST	ROVE			
593	2	1	3.442	0.338	2	V					
593	3	1	3.522	0.318	2	H					
593	4	1	3.744	0.352	1	V					
593	5	1	3.465	0.282	1	H					
593	6	1	3.751	0.348	2	V					
593	7	2	0.000	0.000	.						
593	8	1	3.366	0.275	2	H	ROST	ROVE			
593	9	1	3.504	0.362	1	V					
593	10	1	3.603	0.329	1	H					
593	11	1	3.476	0.336	1	V	ROST				
593	12	1	3.390	0.303	2	H	ROST	ROVE			
593	13	1	3.265	0.344	2	V					
593	14	1	3.471	0.309	2	H	ROVE	SNRB			
593	15	1	3.429	0.346	1	V	ROVE	SNRB			
593	16	1	3.519	0.310	1	H					
593	17	1	3.556	0.373	1	V					
593	18	1	3.341	0.283	2	H					
593	19	1	3.691	0.355	1	V					
593	20	1	3.460	0.284	2	H	ROST				
593	21	1	3.606	0.353	1	V					
594	1	1	3.437	0.303	1	H					
594	2	1	2.967	0.306	1	V					
594	3	1	3.519	0.308	1	H					
594	4	4	0.000	0.000	.						
594	5	1	3.024	0.276	2	V					
594	6	1	3.556	0.298	1	H					
594	7	1	3.133	0.289	2	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
594	8	1	3.688	0.330	2	H					
594	9	1	3.305	0.298	2	V					
594	10	1	3.468	0.303	2	H					
594	11	1	3.416	0.325	1	V	ROST				
594	12	1	3.568	0.303	2	H					
594	13	1	3.293	0.314	2	V					
594	14	1	3.347	0.303	2	H					
598	1	1	3.155	0.272	2	V	ROST	ROVE			
598	2	1	3.236	0.245	1	H	ROST				
598	3	2	0.000	0.000	.						
598	4	1	3.274	0.245	1	V	ROST				
598	5	1	3.683	0.294	1	H	ROST	ROVE			
598	6	1	3.413	0.273	2	V	ROST	ROVE			
598	7	1	3.453	0.278	1	H	ROST	SNRB			
598	8	1	3.271	0.300	2	V	ROST				
598	9	1	3.501	0.282	1	H	ROST				
598	10	1	3.423	0.291	1	V	ROST				
598	11	2	0.000	0.000	.						
598	12	1	3.253	0.265	2	H	ROST				
598	13	1	3.105	0.271	2	V	ROST				
598	14	1	3.341	0.268	2	H	ROST				
598	15	1	3.357	0.283	1	V	ROST				
598	16	1	3.355	0.258	1	H	ROST	ROVE			
599	1	1	3.201	0.325	2	V					
599	2	1	3.200	0.265	1	H	ROVE				
599	3	1	3.226	0.251	1	V					
599	4	1	3.436	0.277	1	H	ROST				
599	5	1	3.285	0.280	1	V	ROVE	SNRB			
599	6	1	3.458	0.283	2	H					
599	7	1	3.149	0.253	1	V	ROVE				
599	8	1	3.529	0.267	1	H					
599	9	1	3.442	0.278	1	V	ROST	ROVE			
599	10	1	3.501	0.302	2	H					
599	11	1	3.274	0.348	2	V	ROST				
599	12	1	3.203	0.242	2	H	MAST				
599	13	1	3.327	0.297	2	V	MSST				
599	14	2	0.000	0.000	.						
599	15	1	3.370	0.267	1	H	ROVE				
599	16	2	0.000	0.000	.						
608	1	1	3.219	0.317	2	V	ROST				
608	2	1	3.666	0.336	1	H					
608	3	1	3.677	0.359	2	V					
608	4	1	3.226	0.278	2	H	ROST	SNRB			
608	5	1	3.414	0.293	2	V	ROST				
608	6	1	3.603	0.324	2	H	ROVE				
608	7	1	2.808	0.238	2	V	ROST				
608	8	1	2.896	0.247	2	H	ROST	ROVE			

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
608	9	1	3.338	0.277	2	V	ROST				
608	10	1	3.264	0.257	2	H	ROVE				
608	11	1	3.210	0.283	2	V					
608	12	1	3.541	0.266	1	H	ROST				
608	13	1	3.132	0.242	2	V	ROST				
608	14	1	3.487	0.310	2	H	ROST				
608	15	1	3.383	0.296	2	V	SNRB				
608	16	1	3.295	0.290	2	H	ROST				
608	17	1	3.352	0.299	2	V	ROST	MAST	MSST	SNRB	
617	1	1	3.770	0.327	1	V					
617	2	2	0.000	0.000	.						
617	3	1	4.094	0.350	1	H					
617	4	1	3.954	0.360	2	V					
617	5	1	3.403	0.294	2	H					
617	6	1	3.690	0.329	1	V					
617	7	1	3.798	0.313	2	H					
617	8	1	4.049	0.323	1	V					
617	9	1	4.225	0.358	1	H					
617	10	1	3.861	0.340	2	V					
617	11	1	3.910	0.313	1	H					
617	12	1	4.119	0.341	1	V					
617	13	1	3.663	0.308	2	H					
617	14	1	4.126	0.316	1	V					
617	15	1	4.023	0.324	1	H					
617	16	1	4.056	0.374	1	V					
617	17	1	3.909	0.327	1	H					
626	1	1	3.563	0.322	1	V	DIUR				
626	2	1	3.365	0.265	2	H					
626	3	1	3.577	0.361	1	V	DIUR	RPCA	ROVE		
626	4	1	3.499	0.288	1	H	MAST				
626	5	4	0.000	0.000	.						
626	6	1	3.227	0.291	2	V	DIUR	ROST			
626	7	1	3.547	0.287	1	H					
626	8	1	3.611	0.304	1	V	DIUR				
626	9	1	3.778	0.274	1	H	ROST				
626	10	1	3.632	0.316	2	V	DIUR				
639	1	1	3.088	0.288	2	H	ROST	ROVE			
639	2	1	3.026	0.298	2	V	ROST				
639	3	1	3.392	0.300	1	H					
639	4	1	3.341	0.294	1	V	ROSK				
639	5	1	3.409	0.293	1	H					
639	6	1	3.342	0.338	2	V					
639	7	1	3.316	0.273	2	H	ROVE				
639	8	1	2.997	0.295	1	V	ROST	ROVE			
639	9	1	3.042	0.263	2	H					
639	10	1	2.963	0.263	2	V					
639	11	1	2.781	0.234	1	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
639	12	1	3.211	0.300	1	V	RUST				
639	13	1	3.031	0.259	2	H	ROST				
639	14	1	3.481	0.338	1	V	MSST				
639	15	1	3.171	0.266	1	H	ROST	ROVE			
639	16	1	3.221	0.326	2	V	ROST	ROVE			
639	17	1	3.310	0.284	1	H					
639	18	2	0.000	0.000	.						
644	1	1	3.494	0.333	2	H	ROVE				
644	2	1	3.395	0.358	1	V	ROST				
644	3	1	3.700	0.307	1	H					
644	4	1	3.653	0.341	2	V					
644	5	1	3.616	0.307	1	H					
644	6	2	0.000	0.000	.						
644	7	1	3.813	0.372	1	V	ROVE	DIUR			
644	8	1	3.132	0.257	1	H					
644	9	1	3.583	0.351	2	V					
644	10	1	3.914	0.344	1	H	ROVE				
644	11	1	3.455	0.325	2	V	ROST	SNRB			
644	12	1	3.584	0.324	1	H					
644	13	1	3.536	0.370	2	V					
644	14	1	3.746	0.325	1	H	ROST	ROVE			
644	15	1	3.645	0.362	1	V	ROVE				
644	16	1	3.445	0.247	2	H	ROST	MAST			
644	17	1	3.932	0.404	1	V					
644	18	1	3.674	0.310	2	H					
650	1	1	3.745	0.404	1	V	ROSK				
650	2	1	3.815	0.333	1	H					
650	3	1	3.514	0.321	2	V	ROVE				
650	4	1	3.686	0.321	2	H					
650	5	1	3.783	0.412	1	V	ROVE				
650	6	1	3.068	0.284	2	H	RBDE	ROVE	SNRB		
650	7	1	3.903	0.389	1	V					
650	8	1	3.860	0.383	1	H					
650	9	1	2.807	0.249	2	V	ROST	RBDE	ROVE	SNRB	
650	10	1	3.534	0.326	2	H					
650	11	1	3.713	0.387	2	V					
650	12	1	3.616	0.306	2	H	ROST	SNRB			
650	13	1	3.742	0.373	1	V	ROVE	SNRB			
650	14	1	3.449	0.312	2	H	ROVE				
650	15	1	3.697	0.402	1	V					
650	16	1	3.828	0.351	1	H	ROVE				
650	17	1	3.535	0.383	2	V					
652	1	1	3.195	0.285	2	V					
652	2	1	3.344	0.291	1	H	ROST	MAST			
652	3	1	3.130	0.289	1	V	ROVE				
652	4	1	3.557	0.286	1	H	SNRB				
652	5	1	3.300	0.357	2	V	DIUR				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
652	6	1	3.641	0.285	2	H					
652	7	2	0.000	0.000	.						
652	8	1	3.589	0.303	2	V					
652	9	1	3.742	0.309	1	H	ROST				
652	10	1	3.700	0.319	1	V	DIUR				
652	11	1	3.441	0.268	1	H	ROST				
652	12	1	3.518	0.317	1	V	DIUR				
652	13	1	3.147	0.239	2	H	ROST				
652	14	1	3.277	0.268	1	V	DIUR	ROST	MAST	SNRB	
652	15	1	3.218	0.285	2	H					
652	16	1	3.227	0.286	2	V	ROST				
661	1	1	3.858	0.434	2	V					
661	2	1	4.045	0.334	1	H					
661	3	1	4.133	0.360	1	V					
661	4	1	3.707	0.280	1	H	ROST				
661	5	1	3.363	0.299	2	V					
661	6	1	3.838	0.308	1	H					
661	7	1	3.845	0.364	1	V	SNRB				
661	8	1	4.147	0.354	1	H					
661	9	1	3.818	0.301	2	V					
661	10	1	3.740	0.283	1	H	ROST	SNRB			
661	11	1	3.847	0.375	2	V					
683	1	1	3.889	0.420	2	V	ROSK				
683	2	2	0.000	0.000	.						
683	3	2	0.000	0.000	.						
683	4	1	3.715	0.322	1	H	ROVE				
683	5	1	3.774	0.310	2	V					
683	6	1	3.755	0.300	1	H					
683	7	1	3.563	0.374	2	V					
683	8	1	3.687	0.324	1	H					
683	9	1	3.430	0.309	2	V					
683	10	1	3.779	0.348	1	H					
683	11	1	3.691	0.403	1	V	ROST				
683	12	1	3.817	0.294	2	H	ROVE				
683	13	1	3.581	0.328	1	V					
683	14	1	3.186	0.254	2	H	ROVE				
683	15	1	3.636	0.344	1	V	DIUR				
683	16	1	3.582	0.305	1	H	ROVE				
683	17	1	3.614	0.352	1	V					
683	18	1	3.985	0.277	1	H	RBDE				
708	1	1	3.735	0.351	1	V					
708	2	1	3.680	0.318	2	H	ROVE				
708	3	1	3.663	0.337	2	V					
708	4	1	3.481	0.292	2	H					
708	5	1	3.567	0.344	1	V	ROVE				
708	6	1	3.581	0.309	1	H	ROST	SNRB			
708	7	1	3.537	0.319	2	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

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Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
708	8	1	3.237	0.294	2	H					
708	9	1	3.427	0.320	2	V					
708	10	1	3.376	0.282	1	H	ROVE				
708	11	2	0.000	0.000	.						
708	12	1	3.671	0.331	1	V	ROVE				
708	13	1	3.489	0.327	2	H	ROVE				
708	14	1	3.638	0.328	1	V	DIUR	ROVE			
721	1	1	3.509	0.345	1	V					
721	2	1	3.624	0.306	1	H	ROVE				
721	3	1	3.454	0.294	2	V	ROVE				
721	4	1	3.660	0.282	2	H					
721	5	2	0.000	0.000	.						
721	6	1	3.474	0.355	2	V	COST				
721	7	1	3.768	0.305	2	H					
721	8	1	3.856	0.406	2	V					
721	9	1	3.763	0.302	2	H	ROVE				
721	10	1	4.016	0.382	1	V					
721	11	1	3.399	0.287	2	H	ROVE				
721	12	2	0.000	0.000	.						
721	13	1	3.626	0.244	1	V					
721	14	1	3.883	0.278	2	H	COST				
721	15	1	3.822	0.263	2	V	DIUR				
721	16	2	0.000	0.000	.						
721	17	1	4.268	0.363	2	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
389	1	1	3.012	0.306	1	V	ROSK	ROST			
389	2	2	0.000	0.000	.						
389	3	1	3.025	0.279	2	H					
389	4	1	3.267	0.375	1	V					
389	5	1	3.620	0.309	1	H					
389	6	1	3.451	0.366	1	V	ROST				
389	7	1	3.294	0.300	2	H					
389	8	1	3.376	0.348	2	V					
389	9	4	0.000	0.000	.						
389	10	1	3.239	0.278	1	H					
389	11	1	3.130	0.358	2	V					
389	12	1	3.316	0.247	1	H					
389	13	1	3.398	0.322	1	V	DIUR				
389	14	1	3.733	0.325	1	H	ROVE				
389	15	1	3.851	0.398	1	V					
407	1	1	2.483	0.199	2	H	ROST	ROPB			
407	2	1	2.911	0.255	2	V	ROPB				
407	3	1	3.149	0.239	1	H	ROST	ROPB			
407	4	1	2.642	0.222	2	V	ROST	ROPB			
407	5	1	2.827	0.193	2	H	ROST	ROVE			
407	6	1	2.828	0.201	1	V	ROST	ROPB			
407	7	2	0.000	0.000	.						
407	8	1	3.282	0.230	1	H					
407	9	1	2.976	0.251	2	V	ROST				
407	10	1	2.972	0.209	1	H	ROST				
407	11	1	2.880	0.249	2	V					
407	12	1	2.999	0.244	1	H					
407	13	1	2.940	0.265	1	V	ROST	SNRB	ROPB		
407	14	1	3.293	0.243	1	H					
407	15	1	3.164	0.257	1	V	ROST				
407	16	1	3.021	0.253	2	H	ROST				
411	1	1	2.158	0.173	2	H	ROST	MAST	ROVE	SNRB	
411	2	1	2.838	0.251	1	V	ROST				
411	3	1	2.822	0.225	2	H					
411	4	1	2.820	0.191	2	V	ROST				
411	5	1	2.992	0.211	1	H					
411	6	1	2.893	0.244	2	V					
411	7	1	2.114	0.136	2	H	ROST	SNRB	ROPB	ROPH	
411	8	1	3.019	0.259	1	V	ROST	ROPB			
411	9	2	0.000	0.000	.						
411	10	1	2.562	0.193	2	H	ROST				
411	11	1	2.694	0.192	2	V	ROST				
411	12	1	3.016	0.270	1	H	ROST				
411	13	1	2.765	0.237	1	V	ROST	ROPB	ROPH		
411	14	1	2.702	0.225	2	H	ROST				
411	15	1	2.720	0.249	1	V	ROST	ROVE			
411	16	1	2.690	0.216	2	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
411	17	1	2.640	0.234	1	V	ROST				
411	18	1	3.002	0.256	1	H	ROST				
411	19	1	2.371	0.188	2	V	ROST	ROPB			
411	20	1	2.964	0.237	1	H					
411	21	1	2.737	0.241	2	V	ROST	ROVE			
411	22	1	2.772	0.225	1	H	ROST	SNRB			
411	23	1	2.912	0.283	2	V					
421	1	1	2.790	0.262	2	V	ROST	ROPB			
421	2	1	3.325	0.304	2	H					
421	3	2	0.000	0.000	.						
421	4	2	0.000	0.000	.						
421	5	1	3.302	0.320	1	V					
421	6	1	3.442	0.290	2	H	ROVE				
421	7	1	3.288	0.300	1	V	ROST				
421	8	1	2.989	0.245	2	H	ROPH				
421	9	1	3.425	0.373	2	V	ROPB				
421	10	1	3.190	0.272	2	H	ROST				
421	11	2	0.000	0.000	.						
421	12	1	3.079	0.303	1	V	ROPH				
421	13	1	3.268	0.274	2	H					
421	14	1	3.064	0.294	2	V	ROST	ROPB			
421	15	1	3.039	0.272	2	H	ROST	ROVE			
421	16	1	2.972	0.208	2	V	ROST	ROPH			
421	17	1	3.194	0.253	1	H					
421	18	1	3.095	0.292	1	V	ROST				
421	19	1	3.358	0.319	2	H	ROPB	ROPH			
446	1	1	2.659	0.199	1	H	ROST	ROPB	ROPH		
446	2	1	2.210	0.195	2	V	ROSK	ROST	ROVE	ROPB	ROPH
446	3	1	3.227	0.239	1	H					
446	4	1	3.008	0.274	2	V	ROSK	ROST			
446	5	1	2.790	0.192	2	H	ROST	ROVE	ROPB	ROPH	
446	6	1	3.210	0.304	2	V	ROSK	ROVE			
446	7	1	3.093	0.279	2	H	ROST	ROVE			
446	8	1	3.142	0.264	1	V	ROST	ROPB			
446	9	2	0.000	0.000	.						
446	10	1	3.179	0.253	1	H	ROST				
446	11	1	2.893	0.262	2	V					
446	12	1	3.131	0.260	2	H	ROST	MAST	ROPH		
446	13	1	2.983	0.338	2	V					
446	14	1	3.088	0.254	2	H	ROST	ROVE			
446	15	1	2.946	0.285	1	V	ROST	ROVE	SNRB		
446	16	1	2.877	0.239	2	H	ROST				
446	17	1	3.202	0.332	2	V	ROST				
446	18	1	2.763	0.220	1	H	ROST	ROPB			
446	19	1	3.154	0.311	2	V					
446	20	1	2.993	0.286	2	H	ROST	ROVE	ROPB		
446	21	1	2.912	0.280	2	V	ROVE				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
457	1	1	3.737	0.227	2	V	EDEM				
474	1	1	3.348	0.287	1	H	ROST				
474	2	1	3.355	0.317	1	V	ROST				
474	3	1	2.875	0.236	1	H	ROST	ROVE			
474	4	1	3.339	0.335	2	V	ROST	ROVE			
474	5	1	2.255	0.171	2	H	ROST				
474	6	1	3.150	0.308	2	V					
474	7	1	2.450	0.190	2	H	ROST	ROVE			
474	8	1	2.943	0.282	2	V	ROVE				
474	9	1	3.008	0.258	2	H	ROST	ROVE			
474	10	1	3.262	0.313	1	V					
474	11	1	2.964	0.250	2	H					
474	12	1	2.978	0.294	1	V	ROVE				
474	13	1	3.036	0.280	2	H	ROST	ROVE			
474	14	1	2.640	0.259	2	V	MIIN	DIUR	ROST	ROVE	
474	15	1	3.022	0.290	2	H	ROST				
474	16	1	3.160	0.305	1	V	ROST				
474	17	1	3.012	0.264	1	H	ROVE				
494	1	1	2.588	0.209	2	H	ROST	ROVE			
494	2	1	2.726	0.207	2	V	ROSK	ROST	ROVE		
494	3	1	2.945	0.206	1	H	ROST				
494	4	1	3.188	0.257	1	V	ROSK	ROVE			
494	5	1	2.906	0.221	2	H					
494	6	1	3.336	0.275	1	V					
494	7	1	3.166	0.217	1	H					
494	8	1	3.215	0.221	2	V	ROVE				
494	9	1	3.219	0.296	1	H					
494	10	1	3.539	0.274	1	V					
494	11	1	3.112	0.184	2	H					
494	12	4	0.000	0.000	.						
494	13	4	0.000	0.000	.						
494	14	4	0.000	0.000	.						
494	15	1	2.509	0.237	1	V					
494	16	1	3.009	0.235	2	H					
494	17	2	0.000	0.000	.						
494	18	1	3.704	0.299	1	V	ROVE				
499	1	1	3.012	0.275	2	H					
499	2	1	2.932	0.303	2	V	ROSK				
499	3	1	3.241	0.313	1	H					
499	4	1	3.179	0.344	2	V	ROST				
499	5	1	3.280	0.326	1	H					
499	6	1	3.391	0.340	1	V	SNRB	ROST			
499	7	1	3.467	0.368	2	H	CLPA				
499	8	1	2.995	0.326	2	V					
499	9	1	3.089	0.307	2	H	ROST				
499	10	1	3.202	0.336	2	V					
499	11	1	2.794	0.254	2	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
499	12	1	3.332	0.402	1	V					
499	13	1	3.174	0.325	2	H	ROST				
499	14	1	3.212	0.340	1	V	ROST				
499	15	1	3.153	0.298	1	H					
499	16	1	3.053	0.301	1	V					
499	17	1	3.235	0.324	1	H					
499	18	1	3.163	0.395	2	V	ROST				
518	1	1	3.362	0.360	1	V	ROVE				
518	2	1	3.221	0.320	1	H	ROVE				
518	3	1	3.495	0.357	1	V					
518	4	1	3.216	0.287	2	H					
518	5	1	3.248	0.297	1	V	ROVE				
518	6	1	3.226	0.271	1	H	ROST	ROVE			
518	7	1	3.551	0.344	1	V					
518	8	1	3.325	0.292	2	H	ROVE				
518	9	1	3.353	0.298	1	V					
518	10	1	3.063	0.246	2	H	ROST	ROVE			
518	11	1	3.319	0.337	2	V	ROSK	ROVE			
518	12	1	3.375	0.298	2	H	MSST				
518	13	1	3.460	0.318	1	V	ROVE				
518	14	1	3.247	0.303	1	H	RBDE				
518	15	1	3.571	0.349	1	V	ROVE				
574	1	1	2.730	0.192	1	H	ROST				
574	2	1	3.083	0.264	2	V	DIUR				
574	3	1	3.088	0.272	1	H					
574	4	1	3.061	0.290	2	V					
574	5	1	3.266	0.292	1	H	ROST				
574	6	2	0.000	0.000	.						
574	7	1	3.113	0.310	2	V					
574	8	1	3.060	0.284	1	H	SNRB				
574	9	1	3.316	0.303	1	V					
574	10	1	3.120	0.299	2	H	ROST				
574	11	1	2.961	0.318	2	V					
574	12	1	3.074	0.273	2	H					
574	13	1	3.024	0.296	2	V	ROVE				
574	14	1	3.209	0.280	2	H					
574	15	1	3.147	0.290	1	V					
574	16	1	3.212	0.295	1	H					
574	17	1	3.229	0.296	1	V	ROST				
574	18	2	0.000	0.000	.						
574	19	1	2.919	0.239	1	H	ROST				
584	1	1	3.288	0.289	2	H	ROVE				
584	2	1	3.431	0.348	1	V	ROST				
584	3	1	3.065	0.266	1	H					
584	4	1	3.133	0.268	1	V	ROST	ROVE			
584	5	1	3.308	0.280	1	H					
584	6	1	3.350	0.334	1	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
584	7	1	2.919	0.236	1	H	ROST	MAST			
584	8	1	3.254	0.310	2	V					
584	9	1	3.136	0.285	2	H	MSST				
584	10	1	3.198	0.272	2	V					
584	11	1	3.477	0.307	1	H					
584	12	1	2.829	0.236	1	V	ROST				
584	13	1	3.297	0.270	1	H	ROST	SNRB			
584	14	1	3.017	0.297	2	V	ROST				
584	15	1	3.127	0.277	2	H	ROST				
584	16	1	3.302	0.300	1	V					
584	17	1	2.876	0.249	1	H	ROST				
584	18	1	3.033	0.259	2	V	MSST				
584	19	1	3.036	0.263	2	H	MSST				
584	20	1	3.219	0.317	2	V					
584	21	1	3.023	0.272	2	H	ROST				
603	1	1	3.520	0.361	2	V	ROVE				
603	2	1	3.301	0.298	2	H					
603	3	1	3.144	0.287	2	V	SNRB				
603	4	1	3.336	0.280	2	H					
603	5	1	3.244	0.316	2	V					
603	6	1	3.557	0.306	1	H					
603	7	1	3.220	0.288	2	V					
603	8	1	3.504	0.303	1	H					
603	9	1	3.448	0.352	2	V	SNRB				
603	10	1	3.202	0.264	1	H	ROST				
603	11	1	3.658	0.361	1	V					
603	12	1	3.464	0.289	1	H	ROST	MAST			
631	1	1	3.300	0.294	1	V					
631	2	1	3.417	0.310	2	H	ROST				
631	3	1	3.286	0.300	2	V	ROST				
631	4	1	3.586	0.299	2	H					
631	5	1	3.059	0.298	2	V	ROST				
631	6	2	0.000	0.000	.						
631	7	1	3.552	0.329	2	H	ROVE				
631	8	1	3.340	0.287	2	V					
631	9	1	3.578	0.281	1	H					
631	10	1	3.331	0.286	1	V					
631	11	1	3.494	0.305	1	H					
631	12	1	3.285	0.278	1	V					
631	13	1	3.688	0.323	2	H	ROVE				
631	14	1	3.484	0.311	2	V					
631	15	1	2.932	0.241	2	H	SNRB				
631	16	1	3.528	0.303	2	V					
631	17	2	0.000	0.000	.						
631	18	1	3.531	0.294	1	H					
642	1	1	3.150	0.261	2	H	ROST				
642	2	1	3.328	0.331	1	V	ROSK	ROST	ROVE	SNRB	

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
642	3	1	3.329	0.276	1	H	ROST	MAST	SNRB		
642	4	1	3.451	0.317	1	V	ROST	SNRB	ROSK		
642	5	1	3.217	0.257	2	H	ROST				
642	6	1	3.452	0.257	2	V	ROST				
642	7	1	3.277	0.281	2	H	ROST	SNRB			
642	8	1	3.366	0.308	2	V	SNRB				
642	9	1	2.976	0.227	1	H	ROST				
642	10	1	3.052	0.312	1	V					
642	11	1	2.858	0.237	2	H	ROST				
642	12	1	3.284	0.308	2	V	ROST	SNRB	RO E		
642	13	1	3.409	0.306	2	H	ROVE				
642	14	1	3.052	0.306	1	V	ROST				
642	15	1	3.306	0.284	1	H	ROST				
642	16	1	3.373	0.336	2	V	DIUR	RPCA	RUST	SNRB	
642	17	1	3.400	0.299	2	H					
642	18	1	2.829	0.287	2	V	ROST				
663	1	1	3.395	0.347	1	V	ROVE				
663	2	1	3.563	0.375	1	H	ROVE				
663	3	1	3.269	0.318	2	V	ROST				
663	4	1	3.249	0.315	1	H	ROST	MAST	ROVE		
663	5	1	3.198	0.344	2	V	ROSK				
663	6	1	3.095	0.263	1	H	ROST				
663	7	1	3.833	0.368	1	V	ROSK				
663	8	1	3.761	0.328	1	H					
663	9	1	3.520	0.356	2	V					
663	10	2	0.000	0.000	.						
663	11	1	3.115	0.273	1	H	ROST	MAST	ROVE		
663	12	1	3.761	0.382	2	V	ROSK	ROVE			
667	1	1	2.789	0.252	2	V	ROSK	ROST	ROVE		
667	2	1	3.210	0.268	1	H	ROST				
667	3	1	3.309	0.334	1	V	ROST				
667	4	1	3.048	0.241	1	H	ROST				
667	5	1	3.768	0.330	1	V	ROST	SNRB			
667	6	1	3.559	0.304	1	H					
667	7	1	3.821	0.388	1	V	ROVE				
667	8	1	2.934	0.226	2	H					
667	9	1	2.907	0.274	2	V	ROST				
667	10	1	3.509	0.276	1	H	ROVE				
667	11	1	3.166	0.305	2	V	ROST				
667	12	1	3.428	0.262	1	H					
667	13	1	3.323	0.309	1	V	ROST				
667	14	1	3.676	0.314	1	H	ROVE				
667	15	1	3.337	0.157	2	V					
667	16	1	3.243	0.262	2	H					
673	1	1	2.466	0.210	1	V	ROSK	ROST	ROVE	ROPH	ROPB
678	2	1	3.279	0.291	1	H	ROVE				
678	3	1	3.287	0.322	1	V	ROVE				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
678	4	1	3.209	0.272	2	H	ROVE				
678	5	1	3.001	0.269	2	V					
678	6	1	3.038	0.226	2	H	ROST				
678	7	1	3.359	0.269	1	V	ROVE				
678	8	1	3.256	0.296	2	H	ROVE				
678	9	1	2.937	0.269	1	V	ROST	ROVE			
678	10	1	3.043	0.251	2	H					
678	11	1	3.237	0.299	1	V	ROSK	ROVE			
678	12	1	3.052	0.245	2	H	ROVE				
678	13	1	3.178	0.288	2	V	ROSK				
678	14	1	3.165	0.247	1	H					
678	15	1	3.025	0.264	2	V	ROSK				
678	16	1	2.981	0.248	2	H	ROVE	SNRB			
678	17	1	3.540	0.321	1	V	ROVE	SNRB			
678	18	1	3.449	0.307	2	H	ROVE				
687	1	1	3.644	0.408	2	V	ROVE	SNRB			
687	2	1	3.724	0.348	2	H	ROVE				
698	1	4	0.000	0.000	.						
698	2	1	3.068	0.251	1	H					
698	3	1	3.124	0.283	2	V					
698	4	1	3.040	0.251	2	H					
698	5	1	3.119	0.257	2	V					
698	6	1	3.132	0.200	1	H	ROST				
698	7	1	3.359	0.298	1	V	ROST				
698	8	1	3.094	0.265	2	H	RBDE				
698	9	1	2.991	0.261	2	V					
698	10	1	2.858	0.245	1	H	ROST	ROVE			
698	11	1	3.005	0.265	1	V					
698	12	1	3.149	0.280	2	H	RBDE				
698	13	1	3.157	0.312	2	V	ROST	ROVE			
698	14	1	3.474	0.303	1	H	RBDE	ROVE			
698	15	1	3.082	0.282	2	V	ROVE				
698	16	1	3.306	0.292	2	H					
698	17	1	3.224	0.301	1	V					
702	1	4	0.000	0.000	.						
702	2	1	3.604	0.394	2	H					
702	3	1	3.861	0.414	1	V					
702	4	1	3.783	0.390	1	H					
710	1	1	3.188	0.268	1	V	ROST				
710	2	1	3.424	0.258	1	H	ROVE				
710	3	1	3.059	0.248	2	V	ROVE				
710	4	1	3.251	0.272	1	H					
710	5	1	3.405	0.229	1	V	ROST				
710	6	1	2.958	0.157	2	H	ROVE				
710	7	1	2.519	0.230	1	V	ROVE				
710	8	2	0.000	0.000	.						
710	9	1	3.118	0.241	1	H	ROST				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
710	10	1	3.061	0.238	1	V	ROST	ROVE			
710	11	1	3.119	0.319	2	H	ROST	ROVE			
710	12	1	3.648	0.252	1	V	ROVE				
710	13	4	0.000	0.000	.						
710	14	1	3.223	0.322	2	H	ROVE				
710	15	1	3.419	0.267	1	V					
711	1	1	2.569	0.209	2	V	ROPB	ROST	ROVE	ROPH	
711	2	1	2.862	0.185	1	H	ROST				
711	3	1	3.076	0.222	2	V					
711	4	1	3.039	0.220	1	H	ROST				
711	5	1	2.918	0.202	2	V	ROST				
711	6	1	3.127	0.206	1	H	ROST	ROVE			
711	7	1	2.921	0.199	1	V	ROST	ROPB	ROPH		
711	8	1	2.314	0.157	2	H	ROST	ROPH	ROPB		
711	9	1	2.933	0.200	1	V	ROVE				
711	10	1	2.828	0.184	2	H	ROVE				
711	11	1	2.684	0.232	2	V	ROPH	ROSK			
711	12	1	2.739	0.219	2	H	ROVE	ROST			
711	13	1	2.755	0.431	1	V	ROST	ROPH			
711	14	1	2.847	0.191	2	H	ROVE				
711	15	1	3.258	0.229	1	V	ROST	ROPH			
712	1	1	3.088	0.287	1	V	ROVE				
712	2	1	3.483	0.298	1	H					
712	3	1	3.277	0.293	2	V	ROVE				
712	4	1	2.940	0.262	2	H					
712	5	1	2.837	0.256	2	V					
712	6	1	3.168	0.286	2	H	ROVE				
712	7	1	3.416	0.327	1	V					
712	8	1	3.325	0.294	2	H					
712	9	1	3.371	0.306	2	V					
712	10	1	3.156	0.362	2	H					
712	11	2	0.000	0.000	.						
712	12	1	3.019	0.339	2	V	ROVE				
712	13	1	3.110	0.299	2	H	ROVE				
712	14	1	3.293	0.312	1	V	ROVE				
712	15	1	3.369	0.275	1	H					
712	16	1	3.445	0.244	1	V	ROVE				
712	17	1	3.136	0.299	2	H	ROVE				
712	18	1	3.492	0.343	1	V					
712	19	1	3.566	0.275	2	H					
714	1	1	3.170	0.249	2	H					
714	2	1	3.217	0.298	2	V					
714	3	1	3.449	0.296	2	H					
714	4	1	3.402	0.328	2	V					
714	5	1	3.630	0.335	2	H					
714	6	1	3.661	0.319	1	V					
714	7	1	3.814	0.335	2	H	ROVE				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
714	8	1	3.142	0.243	2	V	ROST	ROVE			
714	9	1	3.518	0.296	1	H					
714	10	1	3.374	0.300	2	V	ROVE				
714	11	1	3.250	0.283	2	H					
714	12	1	3.694	0.298	1	V					
714	13	1	3.357	0.232	1	H	SNRB				
714	14	1	2.885	0.198	2	V	ROST				
714	15	1	3.530	0.230	2	H					
714	16	1	3.664	0.276	2	V					
717	1	1	3.308	0.336	2	V					
717	2	1	3.565	0.285	1	H					
717	3	1	3.112	0.238	2	V					
717	4	1	3.230	0.268	1	H	ROVE				
717	5	1	3.458	0.242	1	V					
717	6	1	3.377	0.271	1	H	ROVE				
717	7	1	3.359	0.303	2	V	ROST				
717	8	1	3.429	0.297	1	H					
717	9	1	3.157	0.296	2	V					
717	10	1	3.551	0.299	1	H					
717	11	1	3.180	0.291	2	V					
717	12	1	3.294	0.275	2	H					
717	13	1	3.334	0.313	2	V					
717	14	1	3.581	0.291	2	H					
717	15	1	3.383	0.329	2	V					
717	16	1	3.554	0.357	2	H					
719	1	1	2.991	0.322	2	V					
719	2	1	3.450	0.340	1	H	MAST				
719	3	1	3.406	0.345	1	V					
719	4	1	3.727	0.361	1	H	RBDE				
719	5	1	3.395	0.384	2	V					
719	6	1	3.701	0.339	1	H					
719	7	1	4.096	0.510	1	V					
719	8	1	3.830	0.378	1	H	ROVE				
719	9	1	2.867	0.328	2	V					
719	10	1	3.569	0.342	2	H					
719	11	1	2.984	0.310	2	V	ROST	ROVE			
723	1	1	4.347	0.374	1	H	COST				
723	2	1	4.328	0.471	2	V	DIUR				
723	3	1	3.846	0.317	2	H					
723	4	2	0.000	0.000	.						
723	5	1	4.798	0.478	1	V					
723	6	1	4.707	0.341	1	H					
723	7	1	4.566	0.413	1	V	DIUR				
723	8	1	3.682	0.305	2	H	ROVE				
723	9	1	4.852	0.481	1	V					
723	10	1	4.491	0.431	1	H					
723	11	1	3.958	0.351	1	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Rat Fetal Data

75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Liver wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
723	12	1	4.327	0.363	1	H					
723	13	1	4.451	0.394	1	V	DIUR	ROVE			
723	14	1	3.867	0.325	2	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

Code Sheet for Identification of Fetal Abnormalities

CLPA	Cleft Palate
ENCE	Encephalocele
LMFL	Limb Flexure
MAST	Misaligned Sternebrae
OPEY	Open Eye
RBDE	Rib Defect
ROPB	Reduced Ossification Pelvis
ROPH	Reduced Ossification Phalanges
RORB	Reduced Ossification Rib
ROSK	Reduced Ossification Skull
ROST	Reduced Ossification Sternebrae
ROVE	Reduced Ossification Vertebrae
SNRB	Supernumerary Ribs
STDE	Sternebral Defect

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=0 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
10	1	1	1.252	2	V	ROST	SNRB			
10	2	1	1.269	2	H					
10	3	1	1.268	1	V					
10	4	1	1.164	2	H					
10	5	1	1.262	1	V					
10	6	1	1.130	2	H	SNRB				
10	7	1	1.248	1	V					
10	8	1	1.221	2	H					
10	9	1	1.271	1	V	SNRB				
10	10	1	1.208	2	H					
10	11	1	1.168	2	V	SNRB				
10	12	1	1.210	2	H					
35	1	1	1.464	1	H	SNRB				
35	2	1	1.342	2	V	MAST	SNRB			
35	3	1	1.320	2	H					
35	4	1	1.417	1	V	STDE	SNRB			
35	5	1	1.369	2	H	SNRB				
35	6	1	1.318	1	V					
35	7	1	0.857	1	H	ROST	MAST	SNRB		
35	8	1	1.127	2	V					
35	9	1	1.271	1	H	MAST				
35	10	1	1.182	2	V					
35	11	1	1.216	1	H	MAST				
35	12	1	1.259	1	V	ROST	MAST	STDE	ROVE	
35	13	2	.	.						
35	14	1	1.252	2	H					
35	15	1	1.272	1	V					
35	16	1	1.353	1	H					
44	1	1	1.406	1	V	SNRB				
44	2	1	1.343	2	H					
44	3	1	1.280	2	V	SNRB				
44	4	1	1.328	2	H					
44	5	1	1.455	1	V	SNRB				
44	6	1	1.226	1	H	SNRB				
44	7	1	1.226	2	V	MAST				
44	8	1	1.285	1	H	SNRB				
44	9	1	1.248	2	V	SNRB				
44	10	1	1.276	1	H					
44	11	1	1.374	2	V	MAST				
44	12	1	1.248	2	H					
44	13	1	1.337	2	V					
49	1	1	1.300	2	H	ROST				
49	2	1	1.175	1	V					
49	3	1	1.169	2	H					
49	4	1	1.107	1	V					
49	5	1	1.157	2	H					
49	6	1	1.101	1	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=0 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
49	7	1	1.351	2	H					
49	8	1	1.210	1	V					
49	9	1	1.333	2	H					
49	10	1	1.275	2	V					
49	11	1	1.304	2	H					
49	12	1	1.285	2	V					
49	13	1	1.228	2	H					
49	14	1	1.137	1	V					
158	1	1	1.391	1	H					
158	2	1	1.352	2	V					
158	3	1	1.239	1	H	LMFL				
158	4	1	1.314	1	V					
158	5	1	1.353	2	H	MAST				
158	6	2	.	.						
158	7	1	1.332	1	V					
158	8	1	1.373	1	H	MAST				
158	9	1	1.236	2	V	STDE				
158	10	1	1.316	2	H	MAST				
158	11	1	1.189	2	V					
158	12	1	1.265	2	H					
158	13	1	1.330	1	V					
158	14	2	.	.						
159	1	2	.	.						
159	2	1	1.532	2	H					
159	3	1	1.417	2	V					
159	4	1	1.436	2	H	MAST				
159	5	1	1.303	1	V	MAST				
159	6	1	1.383	1	H	MAST				
159	7	1	1.486	2	V					
159	8	1	1.502	2	H					
159	9	4	.	.						
159	10	1	1.278	1	V	STDE				
159	11	1	1.287	1	H	MAST				
159	12	1	1.372	1	V	MAST				
190	1	1	1.587	2	V					
190	2	1	1.357	2	H	SNRB				
191	1	1	1.478	1	H					
191	2	1	1.449	2	V					
191	3	1	1.374	1	H	MAST				
191	4	2	.	.						
191	5	1	1.515	1	V					
191	6	1	1.433	2	H					
191	7	1	1.488	1	V	MAST				
191	8	2	.	.						
191	9	1	1.515	2	H					
191	10	1	1.481	2	V	MAST				
191	11	1	1.485	1	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=0 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
191	12	1	1.554	2	V					
194	1	1	1.340	1	H					
194	2	1	1.126	2	V	LMFL				
194	3	1	1.308	1	H					
194	4	1	1.216	2	V					
194	5	4	.	.						
194	6	2	.	.						
194	7	1	1.249	1	H					
194	8	1	1.159	2	V					
194	9	1	1.148	2	H					
194	10	1	1.240	2	V					
194	11	1	1.287	1	H					
194	12	1	1.216	2	V					
194	13	1	1.332	2	H					
202	1	1	1.303	1	V	SNRB				
202	2	1	1.327	2	H	SNRB				
202	3	1	1.199	2	V	SNRB				
202	4	1	1.143	2	H	MAST	SNRB			
202	5	1	1.275	1	V	SNRB				
202	6	1	1.152	2	H	SNRB				
202	7	4	.	.						
202	8	1	1.182	2	V	MAST	SNRB			
202	9	1	1.207	2	H	SNRB				
202	10	1	1.279	2	V	ROSK	SNRB			
202	11	1	1.244	2	H	SNRB				
202	12	1	1.327	2	V	ROSK	SNRB			
202	13	1	1.299	2	H	SNRB				
202	14	1	1.282	1	V	ROSK	SNRB			
212	1	1	1.332	1	H					
212	2	1	1.182	2	V					
212	3	2	.	.						
212	4	1	1.219	2	H					
212	5	1	1.362	2	V	MAST				
212	6	1	1.350	1	H	STDE				
212	7	1	1.274	2	V					
212	8	1	1.335	1	H					
212	9	1	1.290	1	V					
212	10	1	1.274	2	H	MAST	ROST	SNRB		
212	11	1	1.179	1	V	SNRB				
212	12	4	.	.						
212	13	1	1.289	1	H	OPEY	SNRB			
212	14	1	1.193	2	V	MAST				
212	15	1	1.324	1	H	SNRB				
212	16	1	1.298	2	V					
240	1	1	1.409	2	H					
240	2	1	1.388	2	V					
240	3	1	1.354	2	H	SNRB				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=0 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
240	4	1	1.353	1	V					
240	5	1	1.350	2	H					
240	6	1	1.338	2	V	SNRB				
240	7	1	1.423	1	H	SNRB				
240	8	1	1.285	2	V					
240	9	4	.	.						
240	10	1	1.253	1	H					
240	11	1	1.362	1	V	SNRB				
240	12	1	1.353	2	H	SNRB				
240	13	1	1.463	1	V					
266	1	1	1.303	1	V					
266	2	1	1.216	2	H					
266	3	1	1.183	1	V	SNRB				
266	4	1	1.025	2	H	SNRB				
266	5	1	1.265	1	V					
266	6	1	1.242	2	H	MAST				
266	7	1	1.262	1	V					
266	8	1	1.217	2	H					
266	9	1	1.145	2	V					
266	10	1	1.213	2	H					
266	11	1	1.271	2	V					
266	12	1	1.113	2	H					
266	13	1	1.218	1	V					
266	14	1	1.199	2	H	MAST	ROST			
290	1	1	1.466	2	H					
290	2	1	1.511	2	V					
290	3	1	1.516	1	H	SNRB				
290	4	1	1.474	1	V					
290	5	1	1.413	2	H	MAST				
290	6	1	1.477	1	V					
290	7	1	1.456	1	H					
290	8	1	1.525	1	V	SNRB				
290	9	1	1.454	1	H					
290	10	1	1.471	1	V	SNRB				
290	11	1	1.518	1	H					
309	1	1	1.450	2	H	MAST	STDE			
309	2	1	1.383	1	V					
309	3	2	.	.						
309	4	1	1.330	2	H					
309	5	1	1.368	2	V	SNRB				
309	6	1	1.280	2	H					
309	7	1	1.490	1	V	MAST				
309	8	1	1.471	1	H					
309	9	2	.	.						
309	10	1	1.528	2	V					
309	11	1	1.513	1	H	SNRB				
309	12	1	1.424	1	V	STDE	SNRB			

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=0 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
309	13	1	1.564	1	H					
315	1	1	1.370	2	H	MAST				
315	2	1	1.331	2	V					
315	3	1	1.358	1	H	MAST	SNRB			
315	4	1	1.364	2	V					
315	5	1	1.391	1	H	SNRB				
315	6	1	1.343	2	V	MAST				
315	7	1	1.392	1	H	SNRB				
315	8	1	1.500	1	V	MAST	STDE	SNRB		
315	9	1	1.421	2	H					
315	10	1	1.425	1	V	MAST				
315	11	1	1.463	1	H	MAST	SNRB			
315	12	1	1.423	1	V					
315	13	1	1.399	2	H					
315	14	1	1.430	1	V	SNRB				
334	1	1	1.507	1	H					
334	2	1	1.451	1	V					
334	3	1	1.382	2	H					
334	4	1	1.383	1	V					
334	5	1	1.400	1	H	MAST				
334	6	1	1.392	1	V					
334	7	1	1.373	2	H					
334	8	1	1.364	1	V					
334	9	1	1.253	2	H					
334	10	1	1.339	2	V					
334	11	1	1.397	1	H					
334	12	1	1.306	2	V	SNRB				
334	13	1	1.367	2	H					
334	14	1	1.422	2	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
3	1	1	1.338	2	V					
3	2	1	1.313	1	H	MAST				
3	3	1	1.321	1	V					
3	4	1	1.275	1	H					
3	5	1	1.218	2	V					
3	6	1	0.980	1	H					
3	7	1	1.301	1	V	SNRB				
3	8	1	1.320	1	H					
3	9	1	1.290	1	V	STDE				
3	10	1	1.357	1	H					
3	11	1	1.444	1	V					
3	12	1	1.263	2	H	ROST				
3	13	1	1.264	2	V					
3	14	1	1.365	1	H					
3	15	2	.	.						
3	16	1	1.303	1	V					
9	1	1	1.485	1	H					
9	2	1	1.404	1	V					
9	3	2	.	.						
9	4	1	0.950	2	H	ROST				
9	5	2	.	.						
9	6	1	1.250	1	V					
9	7	1	1.374	2	H	MAST				
9	8	1	1.265	2	V					
9	9	1	1.320	2	H					
9	10	1	1.250	1	V	ROSK	MAST			
9	11	1	1.298	1	H					
16	1	2	.	.						
16	2	1	1.359	1	H	STDE				
16	3	1	1.287	1	V					
16	4	1	1.133	2	H	ENCE	MAST			
16	5	1	1.204	2	V	ROST				
16	6	1	1.147	2	H	MAST				
16	7	1	1.191	2	V					
16	8	1	1.139	1	H					
16	9	1	1.168	1	V					
16	10	1	1.183	2	H					
16	11	2	.	.						
16	12	1	1.313	1	V					
16	13	1	1.201	2	H	MAST	ROST			
16	14	1	1.195	2	V					
16	15	1	1.214	1	H					
38	1	1	1.357	1	H	SNRB				
38	2	1	1.358	1	V	ROSK				
38	3	1	1.228	2	H	MAST				
38	4	1	1.310	1	V	MAST				
38	5	1	1.202	2	H	ROST				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
38	6	1	1.276	2	V	ROSK				
38	7	1	1.219	2	H	LMFL				
38	8	1	1.325	2	V	MAST				
38	9	2	.	.						
38	10	2	.	.						
38	11	1	1.392	2	H					
48	1	1	1.036	2	V	STDE	ROST			
48	2	1	1.060	2	H					
48	3	1	1.021	2	V	STDE				
48	4	1	1.100	2	H					
48	5	1	1.104	2	V					
48	6	1	1.128	1	H	MAST				
48	7	1	1.108	2	V					
48	8	1	1.033	2	H	STDE				
48	9	1	1.114	2	V					
48	10	2	.	.						
48	11	1	1.109	1	H	STDE				
48	12	1	1.146	1	V	STDE				
48	13	1	0.994	1	H	ROST				
48	14	1	1.023	1	V					
48	15	1	1.071	2	H					
48	16	1	1.088	1	V					
48	17	1	0.840	2	H	STDE				
52	1	1	1.145	1	H					
52	2	1	1.259	2	V					
52	3	1	1.146	1	H					
52	4	1	1.207	2	V					
52	5	1	1.161	2	H					
52	6	1	1.113	1	V	SNRB				
52	7	2	.	.						
52	8	1	1.104	1	H					
52	9	1	1.101	1	V					
52	10	1	1.169	1	H					
52	11	1	1.144	1	V					
52	12	1	1.149	2	H					
52	13	1	1.051	1	V					
52	14	4	.	.						
70	1	1	1.322	2	V					
70	2	1	1.357	2	H					
70	3	1	1.395	1	V	MAST				
70	4	1	1.341	2	H	CLPA	SNRB			
70	5	1	1.338	1	V	STDE				
70	6	1	1.311	2	H					
70	7	1	1.299	2	V	LMFL				
70	8	1	1.332	2	H					
70	9	1	1.354	1	V					
70	10	2	.	.						

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
70	11	1	1.478	1	H	SNRB				
91	1	1	1.309	1	V					
91	2	1	1.335	2	H					
91	3	1	1.381	2	V					
91	4	1	1.277	2	H					
91	5	1	1.186	1	V					
91	6	1	1.269	2	H	MAST	ROST			
91	7	1	1.326	2	V					
91	8	1	1.195	2	H					
91	9	1	1.207	1	V					
91	10	1	1.190	1	H					
91	11	1	1.270	1	V					
91	12	1	1.263	2	H					
91	13	1	1.367	2	V					
94	1	1	1.250	1	V					
94	2	1	1.272	2	H	MAST	ROST			
94	3	1	1.248	2	V					
94	4	1	1.314	1	H					
94	5	1	1.274	1	V					
94	6	1	1.204	2	H					
94	7	2	.	.						
94	8	1	1.280	2	V					
94	9	1	1.262	2	H					
94	10	1	1.222	2	V					
116	1	1	1.339	1	H					
116	2	1	1.359	1	V					
116	3	1	1.409	1	H					
116	4	1	1.352	1	V	MAST	STDE			
116	5	1	1.235	1	H	SNRB				
116	6	1	1.404	2	V	SNRB				
116	7	1	1.352	1	H					
116	8	2	.	.						
116	9	1	1.367	2	V	ROST	STDE			
116	10	1	1.259	2	H					
116	11	1	1.326	2	V	MAST	STDE			
116	12	1	1.377	1	H	STDE				
118	1	1	1.328	1	V	MAST				
118	2	1	1.212	1	H					
118	3	1	1.115	1	V					
118	4	1	1.215	2	H	MAST				
118	5	1	1.194	2	V					
118	6	1	1.302	1	H					
118	7	1	1.224	2	V					
118	8	1	1.214	2	H	MAST	STDE			
118	9	1	1.308	1	V					
118	10	4	.	.						
118	11	1	1.137	2	H	STDE				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
118	12	1	1.146	2	V	MAST				
118	13	1	1.179	2	H					
118	14	1	1.152	2	V	MAST	STDE			
118	15	1	1.303	2	H	LMFL	MAST			
120	1	1	1.637	2	V					
120	2	1	1.492	1	H					
120	3	1	1.475	1	V					
120	4	1	1.482	1	H	SNRB				
120	5	1	1.439	2	V	STDE	SNRB			
120	6	4	.	.						
120	7	1	1.446	1	H	MAST				
120	8	1	1.452	1	V					
120	9	4	.	.						
120	10	1	1.422	1	H	SNRB				
120	11	1	1.494	2	V					
120	12	1	1.402	2	H	SNRB				
120	13	1	1.362	1	V					
127	1	1	1.152	1	H					
127	2	1	1.107	2	V					
127	3	1	1.190	1	H	SNRB				
127	4	1	1.326	2	V					
127	5	1	1.177	1	H	MAST				
127	6	1	1.190	1	V					
127	7	1	1.265	2	H	SNRB				
127	8	1	1.258	1	V	STDE				
127	9	1	1.255	2	H					
127	10	1	1.134	1	V					
127	11	1	1.256	2	H	MAST				
127	12	1	1.192	1	V	MAST				
127	13	1	1.209	1	H					
127	14	4	.	.						
176	1	1	1.421	2	V	STDE				
176	2	1	1.554	2	H					
176	3	1	1.430	1	V	ROSK	STDE			
176	4	1	1.429	1	H					
176	5	1	1.437	1	V					
176	6	1	1.361	2	H	STDE				
176	7	1	1.469	1	V					
176	8	1	1.430	1	H					
176	9	1	1.582	1	V					
176	10	1	1.364	1	H	STDE				
176	11	1	1.499	1	V	STDE				
176	12	1	1.467	2	H					
176	13	1	1.450	1	V	SNRB				
182	1	1	1.128	2	V	ROST				
182	2	1	1.093	1	H	MAST				
182	3	1	1.034	1	V	LMFL	ROST			

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
182	4	1	1.148	1	H	SNRB				
182	5	2	.	.						
182	6	1	1.112	1	V	SNRB	MAST			
182	7	1	1.026	2	H	MAST	ROST			
182	8	1	1.064	2	V	ROST	STDE	SNRB		
182	9	1	1.001	2	H	ROST				
182	10	1	1.029	1	V	MAST				
182	11	1	1.043	1	H					
182	12	4	.	.						
182	13	1	1.030	1	V	MAST	SNRB			
182	14	1	1.015	2	H	MAST	ROST			
182	15	1	1.155	1	V	SNRB				
182	16	1	1.005	2	H	MAST	ROST			
182	17	1	1.085	1	V					
209	1	2	.	.						
209	2	2	.	.						
209	3	2	.	.						
250	1	1	1.419	1	H					
250	2	1	1.313	2	V	SNRB				
250	3	1	1.328	1	H					
250	4	1	1.359	1	V					
250	5	1	1.270	2	H					
250	6	1	1.259	2	V					
250	7	1	1.206	1	H	MAST	SNRB			
250	8	1	1.197	2	V					
250	9	1	1.310	1	H					
250	10	4	.	.						
250	11	1	1.250	2	V					
250	12	4	.	.						
250	13	1	1.197	1	H					
250	14	1	1.139	1	V					
250	15	1	1.056	2	H	MAST				
254	1	1	1.506	1	H					
254	2	1	1.412	1	V					
254	3	1	1.351	2	H					
254	4	1	1.340	1	V					
254	5	1	1.332	2	H					
254	6	1	1.363	1	V					
254	7	1	1.294	2	H					
254	8	1	1.314	1	V	ROST				
254	9	1	1.183	2	H					
254	10	1	1.500	2	V					
254	11	1	1.386	2	H					
254	12	1	1.394	2	V					
278	1	1	1.331	2	H	SNRB				
278	2	1	1.364	2	V	SNRB				
278	3	1	1.325	1	H	SNRB				

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=10 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
278	4	1	1.350	1	V	SNRB				
278	5	1	1.052	2	H					
278	6	1	1.204	2	V	SNRB				
278	7	2	.	.						
278	8	1	1.144	2	H	SNRB				
278	9	1	1.184	2	V	SNRB				
278	10	1	1.172	1	H					
278	11	1	1.223	2	V					
292	1	2	.	.						
292	2	2	.	.						
292	3	2	.	.						
292	4	2	.	.						
292	5	2	.	.						
292	6	2	.	.						
292	7	2	.	.						
292	8	2	.	.						
292	9	2	.	.						
308	1	1	1.161	1	V	ROST	SNRB			
308	2	1	1.063	2	H	SNRB				
308	3	1	0.910	1	V	SNRB				
308	4	1	1.081	2	H	SNRB				
308	5	1	1.192	1	V					
308	6	1	1.175	2	H					
308	7	1	1.053	2	V	SNRB				
308	8	1	1.103	1	H	SNRB				
308	9	1	1.094	2	V					
308	10	1	1.247	1	H	SNRB				
308	11	1	1.163	1	V	MAST	SNRB			
308	12	1	1.141	1	H					
308	13	1	1.114	1	V	SNRB				
308	14	1	1.254	1	H	SNRB				
318	1	1	1.360	1	V					
318	2	1	1.343	1	H					
318	3	1	1.242	1	V	ROST				
318	4	2	.	.						
318	5	4	.	.						
318	6	1	1.277	1	H					
318	7	1	1.349	1	V					
318	8	1	1.169	2	H					
318	9	1	1.176	1	V					
318	10	1	1.262	2	H					
318	11	1	1.314	1	V					
318	12	1	1.261	2	H	MAST	ROST			

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
39	1	1	1.139	2	V	SNRB				
39	2	1	1.309	1	H					
39	3	1	1.159	2	V	SNRB				
39	4	1	1.241	2	H					
39	5	1	1.238	2	V					
39	6	1	1.267	2	H	MAST				
39	7	1	1.177	1	V	SNRB				
39	8	1	1.119	2	H	MAST				
39	9	1	1.190	1	V					
39	10	1	1.279	1	H	SNRB				
39	11	1	1.244	1	V	STDE	SNRB			
39	12	1	1.213	1	H					
43	1	1	1.195	2	V	SNRB				
43	2	1	1.005	2	H	MAST	ROST			
43	3	1	1.229	1	V					
43	4	1	1.128	2	H					
43	5	1	1.064	1	V					
43	6	1	1.117	1	H					
43	7	1	1.151	2	V					
43	8	1	1.201	1	H					
43	9	1	1.330	1	V					
43	10	1	1.221	1	H					
43	11	1	1.197	2	V					
56	1	1	1.195	2	H	ROST	ROVE	RORB	ROPH	
56	2	1	1.226	2	V	ROSK	ROST	MAST	RORB	ROPH
56	3	1	1.286	2	H	ROST	RORB	ROPB	ROPH	
56	4	1	1.203	2	V	ROSK	ROST	ROPH		
56	5	1	1.087	1	H	ROST	SNRB	ROVE	ROPH	ROPB
56	6	1	1.117	1	V	ROSK	ROST	RORB	ROPH	STDE
56	7	1	1.110	1	H					
56	8	1	1.208	2	V	SNRB				
56	9	1	1.202	1	H	SNRB				
56	10	1	1.074	2	V	ROST				
56	11	1	1.063	1	H					
56	12	1	1.039	1	V	MAST	STDE			
83	1	4	.	.						
83	2	4	.	.						
83	3	4	.	.						
83	4	4	.	.						
83	5	4	.	.						
83	6	2	.	.						
83	7	4	.	.						
83	8	4	.	.						
83	9	4	.	.						
83	10	4	.	.						
83	11	2	.	.						
83	12	4	.	.						

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
110	1	1	1.024	2	H					
110	2	1	0.967	2	V					
110	3	1	1.104	1	H					
110	4	1	1.082	1	V					
110	5	1	0.941	2	H	ROST	VTDE			
110	6	1	1.162	1	V					
110	7	1	1.095	2	H					
110	8	1	1.023	2	V	RBDE				
110	9	2	.	.						
110	10	1	1.165	1	H	STDE				
110	11	1	1.052	1	V					
110	12	1	1.112	2	H					
150	1	1	1.256	1	H					
150	2	1	1.163	1	V	MAST				
150	3	1	1.236	2	H	MAST	ROST	STDE		
150	4	1	1.157	2	V					
150	5	1	1.306	1	H	MAST	STDE	ROST		
150	6	1	1.222	1	V	ROSK	MAST	ROST		
150	7	1	1.172	2	H	MAST				
150	8	1	1.142	2	V	MAST				
150	9	1	1.194	1	H	MAST	STDE			
150	10	4	.	.						
150	11	1	1.001	1	V	MAST	ROST	RBDE	SNRB	
150	12	1	0.980	1	H	MAST	STDE	SNRB		
150	13	1	1.122	1	V	ROST	STDE			
150	14	1	1.156	1	H	MAST				
166	1	1	1.265	1	V	SNRB				
166	2	4	.	.						
166	3	1	1.213	1	H					
166	4	1	1.032	2	V	STDE				
166	5	4	.	.						
166	6	1	1.082	2	H	MAST	STDE			
166	7	1	1.105	1	V	MAST	SNRB			
166	8	4	.	.						
166	9	1	1.050	2	H	SNRB				
166	10	1	1.173	1	V					
166	11	1	1.066	1	H					
204	1	1	1.084	1	H					
204	2	1	1.082	2	V	MAST				
204	3	1	1.133	1	H					
204	4	1	1.040	2	V					
204	5	4	.	.						
204	6	1	0.998	2	H	SNRB				
204	7	1	1.108	1	V	SNRB				
204	8	1	1.145	1	H					
204	9	1	1.067	1	V	MAST				
204	10	4	.	.						

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
204	11	1	0.991	2	H	MAST	ROST	SNRB		
204	12	4	.	.						
204	13	1	0.971	2	V	RBDE				
204	14	1	0.962	2	H	SNRB	STDE			
204	15	1	1.052	1	V	SNRB				
204	16	1	0.946	2	H	RBDE	VTDE			
216	1	1	1.255	2	H					
216	2	1	1.216	2	V	ROST				
216	3	1	1.319	2	H					
216	4	1	1.249	1	V					
216	5	1	1.194	2	H	MAST				
216	6	1	1.231	2	V					
216	7	1	1.212	1	H					
216	8	1	1.[illegible]9	2	V					
216	9	1	0.972	1	H	ROST				
216	10	1	1.339	1	V	MAST	VTDE			
223	1	2	.	.						
223	2	2	.	.						
223	3	2	.	.						
223	4	2	.	.						
223	5	2	.	.						
223	6	2	.	.						
223	7	2	.	.						
223	8	2	.	.						
223	9	2	.	.						
223	10	2	.	.						
223	11	2	.	.						
223	12	2	.	.						
223	13	2	.	.						
237	1	4	.	.						
237	2	1	1.077	2	H	CLPA				
237	3	1	1.084	1	H	ROST	STDE			
237	4	1	1.058	2	V	MAST	ROST			
237	5	1	1.200	1	H					
237	6	1	1.146	2	V	ROSK				
237	7	1	1.084	2	H					
237	8	1	1.259	1	V					
237	9	1	1.056	2	H	MAST	ROST			
237	10	1	1.075	2	V					
237	11	1	1.107	2	H					
237	12	1	0.965	2	V					
270	1	1	1.144	1	V					
270	2	1	1.075	1	H					
270	3	1	1.078	1	V	MAST	ROST	SNRB	STDE	
270	4	1	0.997	2	H	SNRB				
270	5	1	1.132	2	V	SNRB				
270	6	1	1.069	2	H					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
270	7	1	1.133	2	V					
270	8	1	1.125	1	H	ROST				
270	9	1	1.097	1	V	ROST				
270	10	1	1.161	1	H	MAST				
270	11	1	1.209	1	V	SNRB				
270	12	1	1.119	1	H	ROST				
270	13	1	1.150	1	V					
270	14	1	1.071	1	H					
270	15	1	1.090	2	V	SNRB				
270	16	1	1.042	2	H	MAST	SNRB			
289	1	2	.	.						
289	2	2	.	.						
289	3	2	.	.						
289	4	2	.	.						
289	5	2	.	.						
289	6	2	.	.						
289	7	2	.	.						
289	8	2	.	.						
289	9	2	.	.						
289	10	2	.	.						
289	11	2	.	.						
289	12	2	.	.						
289	13	2	.	.						
310	1	1	1.134	2	H	MAST				
310	2	1	1.219	1	V	SNRB				
310	3	1	1.131	1	H	CLPA	MAST	SNRB		
310	4	1	1.024	2	V	SNRB				
310	5	1	1.155	1	H	MAST				
310	6	1	1.162	1	V					
310	7	1	1.177	1	H	SNRB				
310	8	1	1.088	2	V	SNRB				
310	9	1	1.144	2	H	SNRB				
310	10	1	1.172	2	V	SNRB				
310	11	1	1.089	2	H	MAST	SNRB			
310	12	1	1.134	1	V	SNRB				
310	13	1	1.195	1	H					
310	14	1	1.198	2	V	ROST	SNRB			
310	15	1	1.095	1	H	SNRB				
324	1	1	1.347	1	H					
324	2	2	.	.						
324	3	1	1.256	2	V					
324	4	1	1.171	2	H	MAST	ROST			
324	5	1	1.149	1	V	MAST				
324	6	1	1.150	2	H	MAST				
324	7	1	1.282	2	V	MAST				
324	8	1	1.177	1	H	LMFL	MAST			
324	9	1	1.293	2	V					

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=37 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
324	10	1	1.299	1	H	MAST	ROST			
324	11	1	1.230	1	V					
324	12	1	1.266	2	H					
324	13	1	1.163	2	V					
324	14	1	1.291	1	H					
350	1	2	.	.						
350	2	2	.	.						
350	3	2	.	.						

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
27	1	2	.	.						
27	2	2	.	.						
27	3	2	.	.						
27	4	2	.	.						
27	5	2	.	.						
34	1	2	.	.						
34	2	2	.	.						
34	3	2	.	.						
34	4	2	.	.						
34	5	2	.	.						
34	6	2	.	.						
34	7	2	.	.						
34	8	2	.	.						
34	9	2	.	.						
34	10	2	.	.						
88	1	2	.	.						
88	2	1	0.982	2	H	MAST	ROST			
88	3	1	0.983	2	V	MAST	SNRB			
88	4	1	0.992	1	H	SNRB				
88	5	1	0.921	2	V	ROST	SNRB	MAST	RBDE	
88	6	1	1.100	1	H	MAST				
88	7	1	1.021	1	V	ROST	SNRB	STDE		
88	8	1	0.930	2	H	ROST	SNRB			
88	9	2	.	.						
88	10	1	0.911	2	V	ROST	SNRB			
88	11	1	0.910	2	H	MAST	ROST	SNRB		
88	12	2	.	.						
88	13	1	0.970	2	V	ROST				
88	14	2	.	.						
106	1	4	.	.						
106	2	1	1.008	2	H					
106	3	1	1.088	2	V	STDE	VTDE			
106	4	1	1.121	1	H	MAST	STDE	ROST		
106	5	1	1.039	2	V	ROST	SNRB			
106	6	1	0.911	1	H	MAST	ROST	STDE		
106	7	1	1.130	1	V	ROVE	STDE			
106	8	1	1.020	2	H	STDE				
106	9	2	.	.						
106	10	1	1.124	2	V	MAST	ROST	STDE		
106	11	1	1.179	1	H					
106	12	1	1.116	2	V	STDE	ROVE			
106	13	1	1.131	2	H	ROVE	STDE			
106	14	1	1.092	1	V	ROVE	STDE	VTDE		
114	1	2	.	.						
114	2	2	.	.						
114	3	2	.	.						
114	4	2	.	.						

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
114	5	2	.	.						
114	6	2	.	.						
114	7	2	.	.						
114	8	2	.	.						
114	9	2	.	.						
114	10	2	.	.						
114	11	2	.	.						
114	12	2	.	.						
164	1	2	.	.						
164	2	2	.	.						
164	3	2	.	.						
164	4	2	.	.						
164	5	2	.	.						
164	6	2	.	.						
164	7	2	.	.						
164	8	2	.	.						
164	9	2	.	.						
164	10	2	.	.						
164	11	2	.	.						
164	12	2	.	.						
167	1	1	1.021	1	H					
167	2	1	1.137	1	V					
167	3	1	1.028	2	H	ROST				
167	4	1	0.952	2	V	MAST				
167	5	1	1.113	1	H					
167	6	1	1.127	1	V	MAST	ROST	STDE		
167	7	1	1.057	1	H	MAST	ROST			
167	8	1	1.059	2	V					
167	9	1	0.989	1	H					
167	10	1	0.979	2	V	MAST	ROST	STDE		
167	11	1	1.027	2	H	MAST	ROST			
167	12	1	0.980	1	V	MAST	ROST			
167	13	1	1.150	1	H					
168	1	1	1.133	2	H	SNRB				
168	2	1	1.250	1	V	SNRB				
168	3	1	1.150	2	H	SNRB				
168	4	1	1.187	1	V	SNRB				
168	5	1	1.113	2	H	SNRB				
168	6	1	1.101	1	V	MAST	SNRB			
168	7	1	1.027	2	H	MAST				
168	8	1	1.139	2	V	SNRB				
168	9	1	1.238	1	H					
168	10	1	1.135	1	V	SNRB				
168	11	1	1.046	2	H	MAST	STDE	SNRB		
168	12	1	1.094	2	V					
168	13	1	1.133	1	H	SNRB				
168	14	1	1.043	2	V	ROST	MAST			

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
168	15	1	1.105	2	H	MAST				
168	16	1	1.170	2	V	SNRB				
168	17	1	1.118	2	H	MAST	SNRB			
205	1	4	.	.						
205	2	4	.	.						
205	3	4	.	.						
205	4	4	.	.						
205	5	4	.	.						
205	6	4	.	.						
205	7	4	.	.						
205	8	4	.	.						
205	9	4	.	.						
205	10	4	.	.						
205	11	4	.	.						
205	12	4	.	.						
205	13	4	.	.						
205	14	4	.	.						
210	1	1	1.114	1	H	SNRB				
210	2	1	0.849	2	V	ROST	MAST	STDE		
210	3	1	1.139	1	H	CLPA				
210	4	1	1.108	1	H	CLPA	MAST			
210	5	1	1.110	1	V	MAST	STDE			
210	6	4	.	.						
210	7	1	1.107	1	H					
210	8	1	1.115	2	V	SNRB				
210	9	1	1.210	2	H					
210	10	1	1.225	2	V	STDE				
210	11	1	1.204	2	H					
210	12	1	1.239	1	V	MAST	STDE	RBDE	VTDE	
210	13	1	1.240	1	H					
238	1	2	.	.						
238	2	2	.	.						
238	3	2	.	.						
238	4	2	.	.						
238	5	2	.	.						
238	6	2	.	.						
238	7	2	.	.						
238	8	2	.	.						
238	9	2	.	.						
264	1	2	.	.						
264	2	2	.	.						
264	3	2	.	.						
264	4	2	.	.						
264	5	2	.	.						
264	6	2	.	.						
264	7	2	.	.						
264	8	2	.	.						

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

SAS

Inhalation Developmental Toxicity Study of Gallium Arsenide in Rodents: Raw Mouse Fetal Data

TMT=75 mg/m3 Gallium Arsenide

Matno	Site	Status	Fetal Wt(g)	Sex	Head or Visceral	Abn 1	Abn 2	Abn 3	Abn 4	Abn 5
264	9	2	.	.						
264	10	2	.	.						
264	11	2	.	.						
264	12	2	.	.						
280	1	2	.	.						
280	2	2	.	.						
280	3	2	.	.						
280	4	2	.	.						
280	5	2	.	.						
280	6	2	.	.						
280	7	2	.	.						
280	8	2	.	.						
280	9	2	.	.						
280	10	2	.	.						
280	11	2	.	.						
280	12	2	.	.						
280	13	2	.	.						
280	14	2	.	.						
280	15	2	.	.						
346	1	1	1.203	2	V					
346	2	1	1.211	1	H					
346	3	1	1.299	2	V	MAST				
346	4	1	1.295	1	H					
346	5	1	1.216	2	V					
346	6	1	1.267	2	H	MAST	ROST			
346	7	1	1.189	1	V					
346	8	1	1.226	2	H					
346	9	1	1.217	2	V	ROSK				
346	10	1	1.206	1	H					
346	11	1	1.216	2	V	SNRB				
346	12	1	1.184	1	H					
346	13	1	1.113	2	V					
346	14	1	1.138	1	H	ROST	SNRB			

Status: 1 = Live; 2 = Early Resorption; 4 = Late Resorption; 5 = Dead
Sex: Male = 1; Female = 2;

APPENDIX F

PROTOCOL AND CAGE MAPS
Study Protocol
Cage Maps

Study Protocol

STUDY PROTOCOL

Inhalation Developmental Toxicity Study of Gallium Arsenide in Mice and Rats

Submitted to:

Dr. Bernard Schwetz
Dr. Richard Morrissey
National Toxicology Program
National Institute Environmental Health Sciences
Research Triangle Park, NC

Submitted by:

Dr. Terryl J. Mast
Battelle - Pacific Northwest Laboratory
Richland, WA 99352

June 26, 1989

INHALATION DEVELOPMENTAL TOXICOLOGY STUDY PROTOCOL
GALLIUM ARSENIDE

I. TITLE:

TERATOLOGY STUDY OF GALLIUM ARSENIDE IN MICE AND RATS

II. INTRODUCTION

Gallium arsenide (GaAs) is a crystalline compound with semiconductor properties that is being used extensively in electro-optical devices, microwave telecommunication systems, and computers (Table 1).

This study will determine the potential for inhaled GaAs to cause developmental toxicity in the CD (Sprague-Dawley) rat and in the CD-1 (Swiss) mouse. Although arsenicals are known to interfere with various aspects of reproduction little is known regarding the toxic properties of gallium or GaAs.

Table 1. Summary of Physical and Chemical Properties Gallium Arsenide

Synonym: gallium monoarsenide	MW: 144.64
Molecular Formula: GaAs	CAS No.: 1303-00-0
Melting Point: 1238°C	RTECS No.: LW8800000
Solubility: soluble in 0.1 M phosphate buffer, pH 7.4	
Dark gray crystalline solid with a metallic sheen	
TLV: None established	

III. SPONSOR AND SPONSOR'S REPRESENTATIVE

A. Sponsor:

National Institute of Environmental Health Sciences
National Toxicology Program (NTP)
P.O. Box 12233;
Research Triangle Park, N.C. 27709

B. Sponsor's Representatives:

Dr. Richard Morrissey
Dr. Bernard Schwetz

IV. TESTING LABORATORY

A. Facility

Battelle - Pacific Northwest Laboratory (PNL)
P.O.Box 999; Richland, Washington 99352

B. Principle Investigator:
Dr. Terryl J. Mast

V. PROPOSED SCHEDULE OF EVENTS (THIS PROPOSED SCHEDULE MAY BE ALTERED. ALL CHANGES WILL BE APPENDED TO THE PROTOCOL.)

		Mice	Rats
A.	Order animals:	4/4/89	
B.	Animals arrive week of:	6/19/89	
C.	Identification of females week of:	7/10/89	
D.	Health screen:	7/10/89	
E.	Prestart audit for GLP compliance:	7/10/89	
F.	Initiate breeding procedures[a]:	[~~7/13/89~~ 7/20/89	~~7/17/89~~ 7/24/89]&A
G.	Initiate exposure; dg 4[a]:	[~~7/18/89~~ 7/25/89	~~7/22/89~~ 7/29/89]&A
H.	Complete exposure[a]:	[~~7/31/89~~ 8/7/89	~~8/6/89~~ 8/13/89]&A
I.	Initiate necropsy[a]:	[~~8/1/89~~ 8/8/89	~~8/7/89~~ 8/14/89]&A
J.	Complete fetal specimen evaluation:	[~~10/1/89~~ 12/15/89]&B	
K.	Submit draft report:	[~~11/11/89~~ 3/1/89]&B	
L.	Submit final report: 45 days after receipt of reviewers comments		

[a]These dates are for the first gestational group per species (gestational group A), there may be up to five gestational groups.

VI. TEST SYSTEM

A. Species: mice and rats

B. Strain:
Mice: CrI:CD-1(ICR)BR;
Rats: Sprague-Dawley [CrI:CD(SD)BR]

C. Number of Animals and Supplier:

Mice from Charles River Breeding Laboratories, Raleigh, NC.
Mice: 90 males
350 females

Rats from Charles River Breeding Laboratories, Raleigh, NC.
Rats: 90 males
350 females

&A Changed 7/24/89 by Ammendment A.
&B Changed 2/5/90 by Ammendment B.

D. Age of Animals Upon Arrival: Mice: 7-8 weeks
Rats: 7-8 weeks

E. Experimental Animals: 40 virgin female mice or rats will be randomly selected and assigned to four dose groups (10/group) from the total female pool (ØB-DT-3BØB). The remaining females will be available for breeding.

[~~E~~ F.][6A] Mating Procedure: (ØB-DT-3BØD) The breeding females (mice, 10-11 weeks; rats, 11-12 weeks of age) will be mated by placing 1 to 4 females with one male overnight. The day that copulation is established will be designated as 0 days of gestation (dg).

[~~F~~ G.][6A] Number of Animals in Study:

	Species		Sex		Animals		Treatment Groups		Total
Sperm-positive Teratology	2	x	1	x	25-30	x	4	=	200-240
Distribution	1	x	1	x	9	x	4	=	36
Virgin	2	x	1	x	10	x	4	=	80
							Total	=	316-356

Note: There will also be [~~10~~ 20][6A] males per species in each exposure chamber from the same shipment. These males will be used for a sperm toxicity study [~~defined under a separate protocol~~ defined by Ammendment A.][6A]

VII. EXPERIMENTAL DESIGN AND DOSE LEVELS

A. Developmental Toxicology Study: Four groups of mated female mice will be exposed to the test chemical on 14 consecutive days (4-17 dg). The mice will be killed on 18 dg for maternal and fetal evaluations.

Four groups of mated female rats will be exposed to the test chemical for 16 consecutive days (4-19 dg). The rats will be killed on 20 dg for maternal and fetal evaluations.

Virgin females of each species will be added to each exposure group to assess toxic effects which may result solely from the state of pregnancy. These animals will be exposed, 14 consecutive days for mice and 16 consecutive days for rats, concurrently with the mated females, and killed one day after their last exposure period.

B. Distribution Study: A distribution study will be conducted to determine the distribution of gallium and arsenic in maternal rat blood and fetal tissue following gestational exposure to gallium arsenide. The tissues to be analyzed will be maternal blood (whole) and homogenized fetal tissue (whole).

[6A] Changed 7/24/89 by Amendment A.

1. Tissues will be analyzed at three time points during the study; 7, 14 and 20 dg. Three females per time point.

2. The "fetal" sample will be an aliquot taken from a homogenous mixture of the entire litter at 7 and 14 dg, and from four homogenized fetuses per litter on 20 dg.

3. All samples will be frozen and the 20 dg samples from the highest exposure group will be analyzed first. If no analyte is present in these tissues then tissues from the lower exposure groups as well as from earlier gestation days for the high group will not be analyzed. If analyte is present in the 20 dg samples from the highest exposure group then the next earlier sampling date will be analyzed as well as samples from the last day of the next lower group, and so forth until no further analyte is found in the samples.

4. Maximim number of samples:
4 groups x 3 sampling dates x 3 rats x 2 tissues = 72 samples
72 samples x 2 elements/sample = 144 analyses

C. Exposure Regimen: Exposure concentrations of gallium arsenide will be 0, 10, 37, and 75 mg/m^3, 6 hr per day, 7 days per week.

D. Selection of Atmospheric Concentrations: Exposure chamber concentrations were selected by NTP based on results of the 14-day repeated dose and the 90-day subchronic inhalation toxicology studies of gallium arsenide conducted at PNL.

[E. Sperm Toxicity Study: Individually identified proven-breeder male rats and mice will be exposed to gallium arsenide for 12 days to assess the short-term effects of gallium arsenide exposure on the male reproductive system and to determine the distribution of gallium and arsenic in the blood and testes of the animals. Zinc levels will also be determined in the testes.

Males will be exposed in whole-body exposure chambers (concurrent with the females) at target concentrations of 0, 10, 37, and 75 mg/m^3 for rats and 0, 1, 10, and 37 mg/m^3 for mice, 6 hours +T_{90} per day, 7 days/week for 12 consecutive days. Exposures will run from 8/5/89 through 8/16/89. Males will be weighed during the week prior to exposure start and randomly assigned to one of four exposure groups using body weight as the blocking variable. Males will be weighed on exposure day 1 and the day after their last exposure day.

Male rats will be killed on 8/17/89 and mice on 8/18/89. Males will be transported to room 303, killed by inhalation of CO_2, shaved, placed in plastic bags, and taken immediately to room 1428 for evaluation. Blood will be collected from the caudal vena cava and placed into a 7-ml vacutainer tube for storage until analyses for gallium and arsenic are performed. The left testis and epididymis will be removed and weighed. Epididymal sperm motility and concentration will be evaluated (ØB-TX-3FØ1). The testis will be placed into a pre-washed scintillation vial (nitric acid soaked followed by an ultrapure water rinse) and frozen for gallium and arsenic analyses. The rat testis will also be analyzed for zinc. The right testis will be fixed in Bouin's solution for 24 hours then transferred to 70% ethanol. PAS-stained slides will be prepared for

shipment to NIEHS for histological evaluation by Dr. Robert Chapin at NIEHS.][+A]

VIII. TEST SYSTEM HOUSING, HANDLING AND ENVIRONMENTAL CONDITIONS

A. Quarantine (ØB-AR-3FØ3)

1. Animal shipping crates will be examined upon arrival for evidence of conditions likely to permit exposure to pathogens (soiled, wet or otherwise damaged).

2. The uncrating will be conducted at the door of the quarantine room. While being removed from the crates the animals will be examined by the staff veterinarian for evidence of shipping stress.

3. The animals will be quarantined and acclimatized in the LSL-II Building for 3-4 weeks prior to the start of the study.

4. During the quarantine/acclimatization period the animals will be housed by sex, approximately 10 mice or 6 rats per cage in wire cages on flush racks. The cage space will meet the requirements stated in the NIH "Guide for Care and Use of Laboratory Animals".

5. During the breeding period the animals will be housed in the quarantine room. Males will be singly caged. Females will be group housed. During the breeding hours (1530 to 0700 hrs), 1-4 females will be placed in the male's cage.

6. Room temperature during the quarantine and exposure periods will be maintained at 75±3°F and relative humidity at [~~50±15~~ 55±15%][&A]. These measurements will be recorded at least twice daily.

[+A] Added 7/24/89 by Amendment A.
[&A] Changed 7/24/89 by Amendment A.

7. Twelve hours light and twelve hours dark will be maintained with light starting at 0600.

8. At least ten animals from each shipment will be randomly selected for pre-exposure health screening (ØB-AR-3FØ2). They will be examined by gross necropsy, histopathology and nasopharyngeal culture for evidence of disease and the presence of potentially pathogenic organisms.

9. The clinical veterinarian will make a visual inspection of the animals to be used in the study just prior to their release for the study (documented on the quarantine/acclimatization record).

10. As an added screen for viral infection, 10 females will be tested at PNL promptly after sacrifice for viral pathogens (ØB-AR-3B1R).

11. Females not selected for the study or health screen will be discarded during the first exposure week. The disposition of these females will be recorded on the Animal Disposition Record and retained in the study files.

B. Exposure Chamber Housing and Environmental Conditions

The exposure chamber doors will be closed throughout the exposure and non-exposure periods, except during animal care procedures.

Exposure chamber temperatures will be maintained at 75 ± 3°F and relative humidities at 55 ± 15%.

Air flow will be maintained at 15±3 CFM and the chamber pressure at approximately 1" water negative with respect to room pressure.

C. Feed (ØB-AR-3FØ5)

1. NTP pre-approved NIH-07 Open Formula Diet (pellets) from Ziegler Bros., Inc., Gardners, PA will be used during the quarantine/acclimatization periods and throughout the duration of the experiment.

2. Feed will be provided *ad libitum* in slot feeders during the experiment, except during exposure hours.

C. Water

1. Fresh softened water (ion exchange softener, Illinois Water Treatment Company, Model 2R-2240, Rockford, IL) will be supplied *ad libitum* at all times. The hardness of the water will be checked approximately once every week. Records will be retained in the LSL-II Building Engineer's office.

2. The automatic watering system (Edstrom Industries, Waterford, WI) will be used throughout the duration of the study.

3. A representative sample of animal drinking water from one of the NTP study rooms will be analyzed for contaminants at least once each calendar year (ØB-AR-3B1S).

D. Identification:

1. All animals, male and female will be individually identified by tail tattoos (AIMS®, Inc., Pascatawny, NJ) during the first weighing session (ØB-AR-3FØF).

2. Males used for breeding will be individually identified and the identity will be used to maintain paternity records.

3. Cage maps (ØB-DT-3BØ3) showing placement of individual animals in each cage unit of the exposure chamber will be prepared and updated as needed. Each exposure chamber will be identified by chamber number and exposure level. The proposed arrangement of the exposure chambers in the room is included in Figure 1.

E. Randomization: (ØB-DT-3BØB) Females outside the weight range of mean ± 20% on the first weighing (at the time of identification) will be discarded prior to selection of virgins. Forty virgin females will then be randomly selected and assigned to treatment groups by means of a computer-assisted randomization program which is based on a single blocking factor, body weight.

The remaining females will be mated and assigned to exposure groups as described above on the day of plug or sperm detection (0 dg).

F. Chamber, Cage, Feeder, and Automatic water Line Sanitation Procedures

(NOTE: Due to the Health and Safety concern of this chemical, there will be special cleaning requirements.

1. Daily Sanitation Procedures (ØB-AR-3FØA)

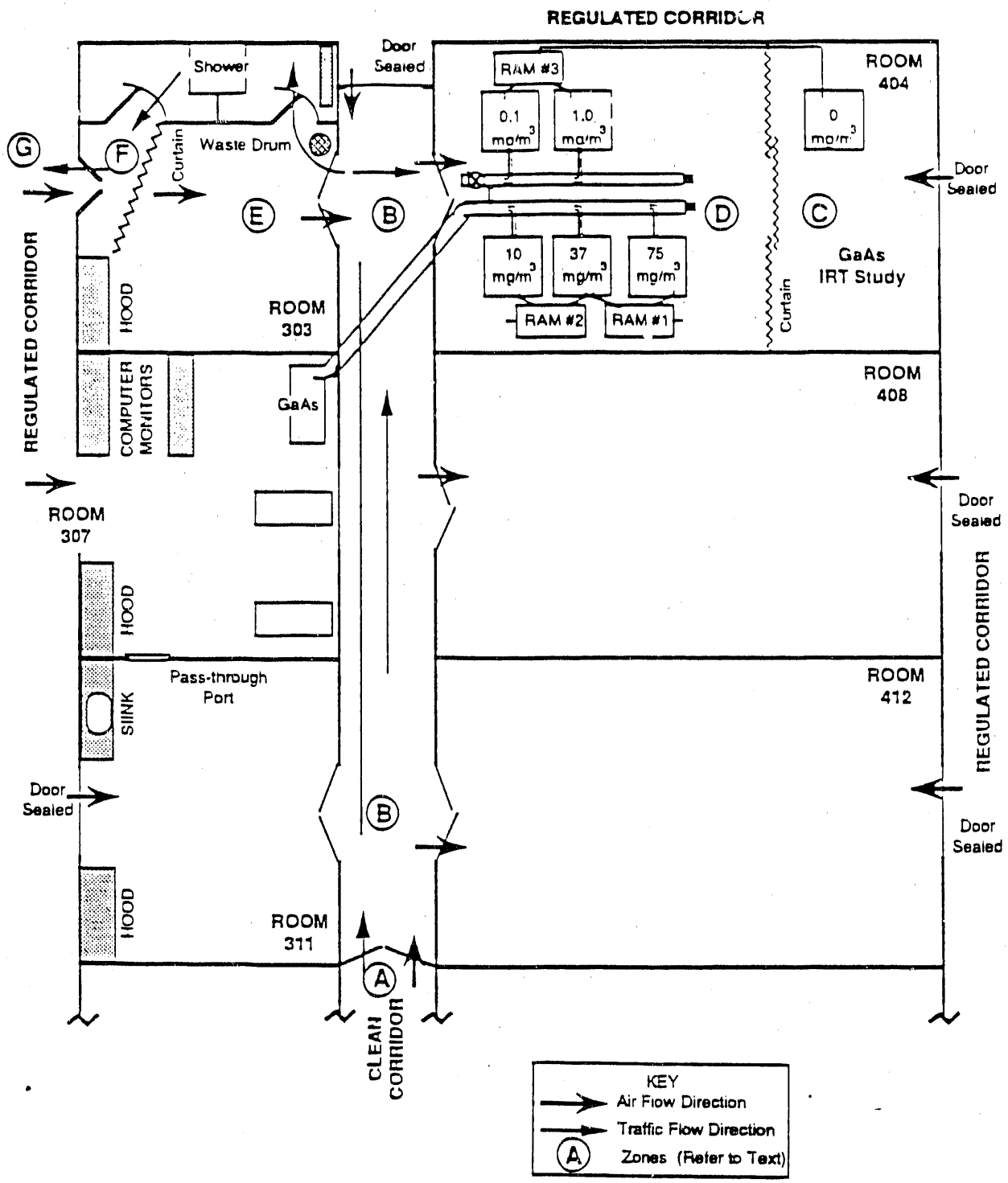
The excreta pans will be changed every day. The soiled pans will be hosed and washed in the exposure room.

Automatic watering systems will be checked daily during animal care procedures to ensure they are functioning properly.

2. Weekly Sanitation Procedures (ØB-AR-3HO1, ØB-AR-3BØ3, ØB-AR-3GØ1)

Chamber and cage units in use will be changed and washed every 7 days.

Each exposure chamber will be changed and washed weekly on a rotational basis starting with the low chamber and rotating each day from the low concentration to the high concentration chamber. The dirty chamber will be disconnected and the animals removed and placed into a clean chamber and cage units. The control chamber will be changed with a clean chamber and will not be part of the rotational scheme described above.



Note: Developmental toxicology animals will be in the 10, 37, and 75 mg/m^3 chambers. Chambers 0.1 and 1.0 mg/m^3 will also be monitored.

Figure 1. Aerosol Exposure Complex Layout Showing Various Work Zones and the Areas Designated for Entry, Exit, and Decontamination.

The automatic water lines in the cage racks and chamber will be flushed with 180-190°F water for a minimum of 1 minute.

The dirty chamber will then be thoroughly cleaned in the exposure room and to be used the next day as the 'clean' chamber for change-out of the next higher concentration chamber.

The individual cage waterers will be checked before the chamber is used.

When the high concentration chamber is cleaned, it will be thoroughly decontaminated, moved to the cage washer and cleaned. The dirty excreta pans designated for cleaning will be moved to the cage washer inside of the dirty chamber. The clean pans will then be returned to the gallium arsenide room.

IX. TEST ARTICLE

A. Test Article

1. Chemical:	Gallium arsenide
2. Formula:	GaAs
3. CAS No:	1303-00-0
4. MRI Lot No.:	MØ51988, Batch 06
5. PNL Assigned Lot No.:	12248-123
6. Manufacturer:	Johnson Matthey Inc. Eagles Landing P.O. Box 1087 Seabrook, NH 03874
7. The vehicle control:	Filtered air
8. Storage conditions:	The test article is stored in a cabinet at room temp (~20°C) in room 311 of the LSL-II Building. To provide more convenient containers for day to day usage, the test article was subdivided into 27, 32 oz jars. A nitrogen blanket was introduced to each jar.

B. Bulk Assay Procedure

1. Midwest Research Institute (MRI) Assay Conclusions:

Bulk material (MRI Lot No. M051988, Batch 06) was identified as gallium arsenide. Cumulative analytical data indicated a purity of >98%.

Elemental analysis results for gallium agreed with theoretical values; however, the results for arsenic were slightly high. The elemental analysis results for gallium were good; 48.1% compared to a theoretical value of 48.2%. A significant amount of oxygen was not found and no organic impurities were found to be present by elemental analysis. Spark source mass spectrometry indicated gallium and arsenic as the major components, with no impurities greater than 100 ppm observed. All other impurities totaled less than 170 ppm by spark source mass spectrometry.

Weight loss upon drying indicated 0.02±0.01% water. Chelometric titration indicated a purity of 98±1%.

2. PNL Assay Conclusions (ØB-AC-3A1R):

Identity of the bulk chemical was confirmed upon receipt by elemental analysis. Subsequent chemical analysis were performed using chelometric titration. The bulk material purity was found to be 99.9% as compared to the MRI provided reference standard.

C. Analysis Schedule

1. The identity and purity of the test material was determined upon receipt. The purity will be performed at a 4-month interval thereafter. An analysis will also be performed within one month of shipment of surplus chemical to the repository.

2. The stability of the test material in the generator hopper was characterized prior to the start of the study.

3. The stability of the test material in the highest and the lowest concentration exposure chambers was characterized prior to the start of the study. This characterization will be repeated with occupied chambers following the initiation of animal exposures.

D. On-Line Real-Time Aerosol Chamber Monitors (ØB-BE-3B3L)

Monitoring of gallium arsenide aerosol within the exposure chambers will be accomplished with Real-time Aerosol Monitors (Model RAM-1, MIE, Inc., Bedford, MA).

On-Line Standard: There will be no on-line standard used for this study. Humidity equilibrated, tared, glass fiber grab filters will be used to collect gallium arsenide from chamber atmospheres every exposure day and weighed as a check of the exposure calibration. At least one sample will be taken for each of the three RAMS used.

Calibration Frequency: Besides weighing the glass fiber filters mentioned above, one set of filters (duplicates from each exposure chamber) will be submitted every two weeks for chemical specific analysis using graphite furnace atomic absorption spectrophotometry. These results will be used to calibrate the RAM-1 on-line monitors.

Control Range: Target concentration ±20%.

Critical Limits: Target concentration ±30%, alarmed (shut off gas flow to the chamber).

Monitoring Frequency: Each chamber and the room will be monitored approximately once every 30 minutes.

X. DESCRIPTION OF INHALATION EXPOSURE SYSTEM

The inhalation chambers will be located in room 404 of the LSL-II building. A detailed description of the inhalation exposure system to be used in this study is included in Attachment 2 of this protocol. The location of the exposure room and chamber layout are shown in Figure 1.

A. Environmental Monitoring

1. Air filtration: HEPA and charcoal filters will be used for intake air, and a HEPA filter will be used for exhaust air. New exhaust and intake filters will be installed prior to the start of the study.

2. Temperatures will be monitored by resistance thermal detectors (RTDs) multiplexed to a digital thermometer with computer data acquisition at approximately 4-hour cycles for 24 hours per day (minimum of 3 measurements per day). The control range is 75±3° F with critical limits, <70 or >80° F. Any chamber temperature excursion beyond the critical limits will be recorded and alarmed automatically.

3. Relative humidity will be monitored by a single dew point hygrometer in conjunction with a multiplexed sampling system with computer data acquisition at approximately 4-hour cycles, 24 hours per day (minimum of 3 measurements per day). The control range is 55±15% with critical limits of <35% or >75%. Any relative humidity excursion beyond the critical limits will be recorded and alarmed automatically.

4. Chamber air flow will be monitored at an exhaust orifice using a multiplexed Validyne pressure transducer system with computer data acquisition at approximately 4-hour cycles, 24 hours per day (minimum of 3 measurements per day). The control range is 15±3 air changes/hour (15±3 CFM) with

critical limits of <10 CFM or >20 CFM. Any chamber flow excursion beyond critical limits will be recorded and alarmed automatically. A critically low flow will result in automatic termination of the exposure. Gallium arsenide concentrations in the chambers may be controlled in part by the adjustment of chamber air flow.

5. Chamber vacuum will be monitored using a multiplexed Validyne pressure transducer system with computer data acquisition at approximately 4-hour cycles, 24 hours per day (minimum of one measurement per day). The control range is -0.2 to -1.5 inches of water pressure with critical limits set at the same values. Any chamber vacuum excursion beyond the critical limits will be recorded and alarmed automatically. If chamber vacuum exceeds the limits of -0.2 inch of water, the exposure will be automatically terminated.

6. Uniformity of the concentration of the test chemical in each of the chambers was established during the 90-day subchronic study. Uniformity measurements will be made at the beginning of the study with the animals in the chambers. A between port and within port variability of ≤ 5% relative standard deviation (RSD) is considered acceptable.

7. Build up and decay times were established during the 90-day subchronic study. Buildup and decay measurements will also be made at the beginning of this study with the animals in the chamber.

8. Particle size distribution of the aerosol in the exposure chambers will be measured once during the study.

B. Effluent Treatment (ØB-AC-3A1S) Chamber exhaust will be HEPA filtered to remove all aerosol. The building exhaust stack will be monitored once to during the study to prove efficiency of the effluent treatment.

XI. EXPERIMENTAL OBSERVATIONS

A. Clinical Observations: (ØB-DT-3BØ3) Study females will be observed twice daily for mortality, morbidity, and signs of toxicity. The date and time of death or euthanasia of moribund animals will be recorded and the animals will be necropsied (ØB-DT-3BØF).

B. Body Weights: All females will be weighed at the time of identification (within one week of mating). Plug-positive mice will be weighed on 0, 4, 6, 9, 12, 15, and 18 dg. Sperm-positive rats will be weighed on 0, 4, 6, 10, 14, 17, and 20 dg. Virgin mice will be weighed on exposure days 1, 3, 6, 9, 12, and at sacrifice. Virgin rats will be weighed on exposure days 1, 3, 7, 11, 14, and at sacrifice.

C. Scheduled Necropsy (ØB-DT-3BØG): Animals will be weighed in the exposure room the morning of sacrifice. They will then be transported in solid bottom cages to room 303, killed by inhalation of 70% CO_2, shaved, placed in plastic bags and taken immediately to room 1428 for evaluation.

1. At necropsy maternal animals will be weighed and examined for gross tissue abnormalities. In order to document the presence of lesions which may be due to chemical exposure, any organs or tissues with lesions will be preserved in neutral buffered formalin (NBF). In this case, comparable organs or tissues from approximately 20% of the control animals will be preserved in NBF. Liver and kidneys will be weighed and tissues discarded unless abnormal.

   The gravid uteri will be weighed, opened and the number, position and status of implants will be recorded. Any apparently non-gravid uteri will be weighed and stained with 10% ammonium sulfide to detect possible implantation sites. The placentas will be examined and preserved in neutral buffered formalin (NBF) if abnormal. Ovarian corpora lutea counts will be obtained for both gravid and non-gravid females. Ovaries (gravid and non-gravid) will be fixed for 24 hr in Bouin's fluid then transferred to 70% ethanol and sent to NTP Archives.(ØB-DT-3FØ2)

2. Virgin mice and rats will be killed on the day after the the last exposure day. Liver and kidney weights will be taken and tissues discarded unless abnormal. Ovaries will be fixed for 24 hr in Bouin's fluid then transferred to 70% ethanol and sent to NTP Archives.(ØB-DT-3FØ2)

D. Fetal Examination (ØB-DT-3BØG):

1. The identity of live fetuses (by study, dam number and implant number) will be retained throughout all examinations. Live fetuses will be examined for gross defects and weighed (ØS-SI-5EØ2). Following euthanasia, a complete visceral examination will be performed on 50% of all live fetuses. Fetal livers will be removed and weighed individually. Sex will be determined on all live fetuses by internal examination of gonads.

2. Approximately 50% of the fetal heads will be removed and examined by razor-blade sectioning of the fixed preparations (ØB-DT-3BØI). All carcasses, with and without heads, will be double-stained and examined for cartilage and centers of ossification (ØB-DT-3BØY). Records of morphologic lesions observed during examinations will include photographs of representative lesions. All fetal specimens will be double bagged and sent to NTP Archives.(ØB-HI-3GØ9, ØB-DT-3FØ2)

F. Indices of Effects: The following parameters will be expressed as mean ± STD, when appropriate.

- Number of dead animals, animals removed from the study and reason for removal
- Summary of observed toxicity, including incidence of changes detected during clinical observations
- Number and percent pregnant
- Maternal body weights:
  Mice on 0, 4, 6, 9, 12, 15 and 18 dg (sacrifice)

Rats on 0, 4, 6, 10, 14, 17,and 20 dg (sacrifice)

- Weight of gravid uterus
- Maternal liver and kidney weights
- Extragestational weight and weight gain
- Number of implantation sites/litter
- Number of litters with live fetuses
- Number and percent of live fetuses/litter
- Body weight of male and female fetuses/litter
- Liver weight of male and female fetuses/litter
- Sex ratio of fetuses/litter
- Number and percent of early and late resorptions/litter
- Number and percent of dead fetuses/litter
- Number and percent of non-live/litter (early and late resorptions and dead fetuses)
- Listing of malformations and variations observed in fetuses/litters
- Number and percent fetuses/litter with malformations (variations)
- Number and percent of litters with malformations (variations)
- Gallium and arsenic levels in maternal blood and fetuses of rats
- Virgin body weights:
  Mice on exposure day 1, 3, 6, 9, 12, and at sacrifice
  Rats on exposure day 1, 3, 7, 11, 14, and at sacrifice
- Virgin liver and kidney weights

XII. PROPOSED STATISTICAL METHODS

The methods proposed for the statistical analyses of representative maternal, reproductive and fetal indices of effects are: summary statistics, N, mean, standard deviation, with accompanying ANOVA based on multiple comparisons where appropriate. Arc sin transformations will be performed on proportional incidence data. Further statistical analyses will be performed as necessary.

XIII. RECORDS RETENTION

Records that accumulate during the study will be retained at PNL until requested and shipped to NTP archives. Some of these records may be presented as part of the protocol or reports. These will include but not be limited to the following records:

A. Personnel Records

1. List of PNL personnel participating in the study.

2. Name, address, and function of any outside consultant(s).

3. Record of removal of any individual from direct contact of the test system due to illness.

B. Health and Safety Records (original records and five copies of microfiche will be submitted to NTP within approximately two months after the end of each fiscal year). Chemical specific records will be submitted with the study. Facility specific records will be submitted annually.

1. Medical records of all personnel participating in the study. These records will be retained by Hanford Environmental Health Foundation (HEHF), P.O. Box 100, Richland, WA 99352 for a minimum of 40 years. A letter verifying this arrangement will be retained for each test material file.

2. Records and results of any biological monitoring on laboratory personnel (if applicable).

3. NTP Health and Safety package for gallium arsenide.

4. PNL biohazard protocols and PNL Health and Safety Plan.

5. Chemical specific health and safety training records.

6. Waste disposal records.

7. Respiratory protection program with documentation of user training (specific fit testing if needed) for each type of respirator.

8. Building ventilation system, hoods and exhausting system monitoring records (pertinent to NTP studies).

9. Health and safety section of the monthly progress reports.

10. Accident/injury reports for personnel involved in this study.

11. NTP site visit reports, attention items and related correspondence on health and safety.

C. Protocols

1. Approved and dated PNL study protocol.

2. Protocol amendments including NTP technical contract modifications which affect the study.

3. Documentation of any deviation from the protocol.

4. Documenting any unforeseen circumstances that may affect the integrity of the study and corrective actions taken.

D. Test Material Records

1. Test material identity records including manufacturer, quantity, lot number(s), purity grade and date(s), etc.
2. NTP analytical contractor characterization reports.
3. NTP analytical contractor bulk stability reports.
4. NTP analytical contractor shipment records (if available).
5. PNL test chemical receipt records.
6. PNL storage records including storage conditions.
7. PNL bulk analysis and degradation records.
8. PNL method development records.
9. Chemical exposure generation system description and procedures.
10. Chamber concentration monitoring records.
11. Uniformity (chamber balance) records.
12. Generation and chamber degradation study records.
13. PNL test material inventory and usage records.
14. Records of shipment to NTP repository of any unused test material.
15. Aerosol determination records.
16. Chamber concentration buildup, decay, and overnight monitoring records.
17. Exposure generation operating parameter records.

E. Animal Records - Pretest

1. Animal receiving records including supplier, species, strain, birth week, sex, number of animals for each sex, receiving date and receiving conditions (photocopy of a representative animal shipping crate label).
2. Quarantine records.
3. Pretest health screening records and animal health notebook.
4. Randomization records.
5. Animal identification records.
6. Written release records from clinical veterinarian.
7. Disposal of excess animals.

8. Bedding type.

F. Animal Records - On Test

1. Exposure room location and chamber layout records.
2. Chamber cage map.
3. Cage type, rack type during study.
4. Cageboard type.
5. Type of watering system.
6. Body weight records.
7. Daily observation records
8. Clinical signs of toxicity records.
9. Serology data and reports.
10. Inventory list of archived specimens

G. Feed

1. Feed tags with manufacturer, lot numbers and milling dates.
2. Feed analysis records as provided by NTP analytical contract laboratory.

H. Water

1. Annual water analysis.
2. Weekly water hardness check (records will be maintained in building engineer and/or building manager's office).

I. Quarantine Room, Exposure Room, and Inhalation Exposure Chamber Records

1. Exposure chamber description.
2. Exposure suite control center description.
3. Temperature raw data and daily and monthly summation reports.
4. Relative humidity raw data and daily and monthly summation reports.
5. Airflow raw data and daily and monthly summation reports.
6. Chamber vacuum raw data and daily and monthly summation reports.
7. Exposure system monitors calibration and maintenance records.
8. Description of the lighting system and light/dark regimen.
9. Sanitation procedures and pest control program.

J. All Relevant Correspondence

K. Reports

1. Monthly Progress Report.
2. Special study reports (if any).
3. Incident reports (if applicable).
4. Final Report.

L. Internal Computer Generated Forms and Tables

1. Developmental toxicology results and statistical analyses.
2. Analytical chemistry results.
3. Exposure suite control center computer printouts.
4. XYBION printouts (if any).

XIV. OTHER SPECIFICATIONS

A. This study will be performed in compliance with the FDA Good Laboratory Practice Regulations for nonclinical laboratory studies (21 CFR 58) except where deviations are required by the NTP April, 1987 General Statement of Work and subsequent modifications.

B. This protocol will be the controlling document in case of discrepancies between the protocol and SOPs. If this occurs the Principal Investigator is to be notified immediately for clarification.

C. A list of all relevant sandard operating procedures (SOPs) for this study are present in Attachment I.

XV. HEALTH AND SAFETY:

PNL's Health and Safety Plan (ØB-HS-3S1C) has been approved by NTP. In addition, a respiratory program is instituted. This is supplemented by using supplied-air respirators (ØB-HS-3S19) which will be worn by personnel at all times when they are in exposure rooms and by having available self-contained breathing apparatus (ØB-HS-3S1A) for use when entering a room under emergency conditions following a leak.

XVI. **APPROVAL BY PNL**

Terryl J. Mast, PhD
Principle Investigator — 6-28-89 Date

Quality Assurance Auditor — 6/28/89 Date

XVII. **APPROVAL BY NTP**

Richard E. Morrissey, PhD
Co-Study Officer — 13 July 89 Date

Bernard A. Schwetz, DVM, PhD
Co-Study Officer — 13 July 89 Date

XVIII. **AMMENDMENTS/REVISIONS**

See the following page.

XVIII. AMENDMENTS/REVISIONS

7/24/89 Amendment A:
Pg. 2: Section V. Change dates on schedule of events due to 1-week study delay.
Pg. 3: Section VI. Correct typing errors and definition of sperm toxicity study.
Pg. 4: Section VII. Addition subsection defining sperm toxicity study.
Section VII. Correct error in relative humidity.

2/5/90 Amendment B:
Pg.2 Section V. Change dates on schedule of events to reflect actual submission of study report.

11/29/90 Amendment C:
Attachment II, Pg. II-19: Figure 5. Correct error in ports and RAM used for calibration purposes.

IV. TESTING LABORATORY

A. Facility

Battelle - Pacific Northwest Laboratory (PNL)
P.O.Box 999; Richland, Washington 99352

B. Principle Investigator:

Dr. Terryl J. Mast

V. PROPOSED SCHEDULE OF EVENTS (THIS PROPOSED SCHEDULE MAY BE ALTERED. ALL CHANGES WILL BE APPENDED TO THE PROTOCOL.)

	Mice	Rats
A. Order animals:	4/4/89	
B. Animals arrive week of:	6/19/89	
C. Identification of females week of:	7/10/89	
D. Health screen:	7/10/89	
E. Prestart audit for GLP compliance:	7/10/89	
F. Initiate breeding procedures[a]:	7/13/89	7/17/89
G. Initiate exposure; dg 4[a]:	7/18/89	7/22/89
H. Complete exposure[a]:	7/31/89	8/6/89
I. Initiate necropsy[a]:	8/1/89	8/7/89
J. Complete fetal specimen evaluation:	10/1/89	
K. Submit draft report:	11/11/89	
L. Submit final report: 45 days after receipt of reviewers comments		

[a]These dates are for the first gestational group per species (gestational group A), there may be up to five gestational groups.

VI. TEST SYSTEM

A. Species: mice and rats

B. Strain:

Mice: CrI:CD-1(ICR)BR;
Rats: Sprague-Dawley [CrI:CD(SD)BR]

C. Number of Animals and Supplier:

Mice from Charles River Breeding Laboratories, Raleigh, NC.
Mice: 90 males
350 females

Rats from Charles River Breeding Laboratories, Raleigh, NC.
Rats: 90 males
350 females

IV. TESTING LABORATORY

A. Facility

Battelle - Pacific Northwest Laboratory (PNL)
P.O.Box 999; Richland, Washington 99352

B. Principle Investigator:
Dr. Terryl J. Mast

V. PROPOSED SCHEDULE OF EVENTS (THIS PROPOSED SCHEDULE MAY BE ALTERED. ALL CHANGES WILL BE APPENDED TO THE PROTOCOL.)

	Mice	Rats
A. Order animals:	4/4/89	
B. Animals arrive week of:	6/19/89	
C. Identification of females week of:	7/10/89	
D. Health screen:	7/10/89	
E. Prestart audit for GLP compliance:	7/10/89	
F. Initiate breeding procedures[a]:	[~~7/13/89~~ 7/20/89	~~7/17/89~~ 7/24/89][&A]
G. Initiate exposure; dg 4[a]:	[~~7/18/89~~ 7/25/89	~~7/22/89~~ 7/29/89][&A]
H. Complete exposure[a]:	[~~7/31/89~~ 8/7/89	~~8/6/89~~ 8/13/89][&A]
I. Initiate necropsy[a]:	[~~8/1/89~~ 8/8/89	~~8/7/89~~ 8/14/89][&A]
J. Complete fetal specimen evaluation:	10/1/89	
K. Submit draft report:	11/11/89	
L. Submit final report:	45 days after receipt of reviewers comments	

[a]These dates are for the first gestational group per species (gestational group A), there may be up to five gestational groups.

VI. TEST SYSTEM

A. Species: mice and rats

B. Strain:
Mice: CrI:CD-1(ICR)BR;
Rats: Sprague-Dawley [CrI:CD(SD)BR]

C. Number of Animals and Supplier:

Mice from Charles River Breeding Laboratories, Raleigh, NC.
Mice: 90 males
350 females

Rats from Charles River Breeding Laboratories, Raleigh, NC.
Rats: 90 males
350 females

[&A] Changed 7/24/89 by Ammendment A.

D. Age of Animals Upon Arrival: Mice: 7-8 weeks
Rats: 7-8 weeks

E. Experimental Animals: 40 virgin female mice or rats will be randomly selected and assigned to four dose groups (10/group) from the total female pool (ØB-DT-3BØB). The remaining females will be available for breeding.

E. Mating Procedure: (ØB-DT-3BØD) The breeding females (mice, 10-11 weeks; rats, 11-12 weeks of age) will be mated by placing 1 to 4 females with one male overnight. The day that copulation is established will be designated as 0 days of gestation (dg).

F. Number of Animals in Study:

	Species		Sex		Animals		Treatment Groups		Total
Sperm-positive									
Teratology	2	x	1	x	25-30	x	4	=	200-240
Distribution	1	x	1	x	9	x	4	=	36
Virgin	2	x	1	x	10	x	4	=	80
							Total	=	316-356

Note: There wil also be 10 males per species in each exposure chamber from the same shipment. These males will be used for a sperm toxicity study defined under a separate protocol.

VII. EXPERIMENTAL DESIGN AND DOSE LEVELS

A. Developmental Toxicology Study: Four groups of mated female mice will be exposed to the test chemical on 14 consecutive days (4-17 dg). The mice will be killed on 18 dg for maternal and fetal evaluations.

Four groups of mated female rats will be exposed to the test chemical for 16 consecutive days (4-19 dg). The rats will be killed on 20 dg for maternal and fetal evaluations.

Virgin females of each species will be added to each exposure group to assess toxic effects which may result solely from the state of pregnancy. These animals will be exposed, 14 consecutive days for mice and 16 consecutive days for rats, concurrently with the mated females, and killed one day after their last exposure period.

B. Distribution Study A distribution study will be conducted to determine the distribution of gallium and arsenic in maternal rat blood and fetal tissue following gestational exposure to gallium arsenide. The tissues to be analyzed will be maternal blood (whole) and homogenized fetal tissue (whole).

1. Tissues will be analyzed at three time points during the study; 7, 14 and 20 dg. Three females per time point.

2. The "fetal" sample will be an aliquot taken from a homogenous mixture of the entire litter at 7 and 14 dg, and from four homogenized fetuses per litter on 20 dg.

3. All samples will be frozen and the 20 dg samples from the highest exposure group will be analyzed first. If no analyte is present in these tissues then tissues from the lower exposure groups as well as from earlier gestation days for the high group will not be analyzed. If analyte is present in the 20 dg samples from the highest exposure group then the next earlier sampling date will be analyzed as well as samples from the last day of the next lower group, and so forth until no further analyte is found in the samples.

4. Maximim number of samples:
4 groups x 3 sampling dates x 3 rats x 2 tissues = 72 samples
72 samples x 2 elements/sample = 144 analyses

C. Exposure Regimen: Exposure concentrations of gallium arsenide will be 0, 10, 37, and 75 mg/m^3, 6 hr per day, 7 days per week.

D. Selection of Atmospheric Concentrations: Exposure chamber concentrations were selected by NTP based on results of the 14-day repeated dose and the 90-day subchronic inhalation toxicology studies of gallium arsenide conducted at PNL.

VIII. TEST SYSTEM HOUSING, HANDLING AND ENVIRONMENTAL CONDITIONS

A. Quarantine (ØB-AR-3FØ3)

1. Animal shipping crates will be examined upon arrival for evidence of conditions likely to permit exposure to pathogens (soiled, wet or otherwise damaged).

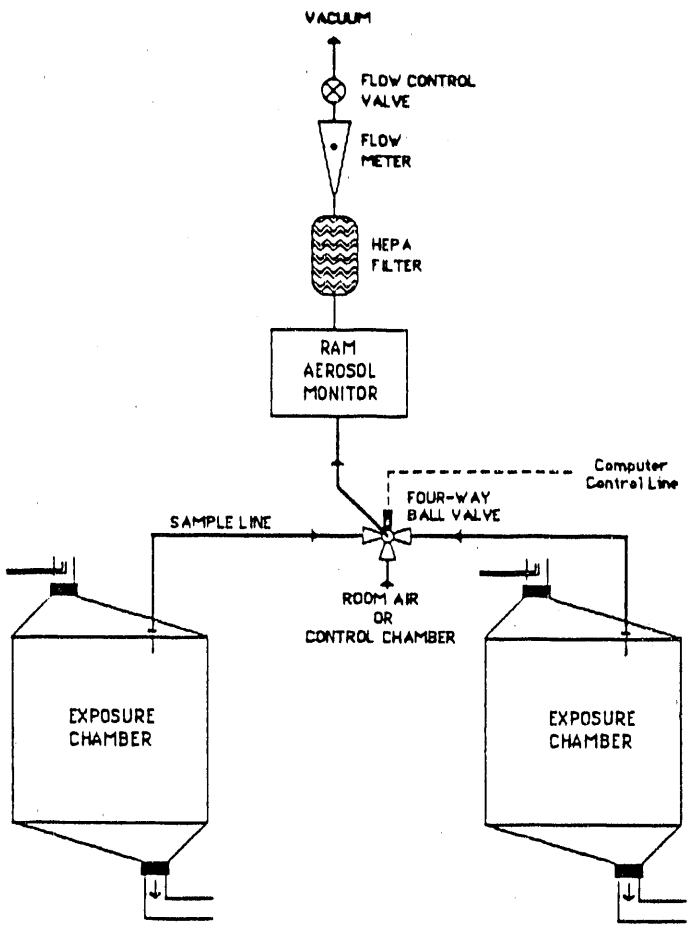
2. The uncrating will be conducted at the door of the quarantine room. While being removed from the crates the animals will be examined by the staff veterinarian for evidence of shipping stress.

3. The animals will be quarantined and acclimatized in the LSL-II Building for 3-4 weeks prior to the start of the study.

4. During the quarantine/acclimatization period the animals will be housed by sex, approximately 10 mice or 6 rats per cage in wire cages on flush racks. The cage space will meet the requirements stated in the NIH "Guide for Care and Use of Laboratory Animals".

5. During the breeding period the animals will be housed in the quarantine room. Males will be singly caged. Females will be group housed. During the breeding hours (1530 to 0700 hrs), 1-4 females will be placed in the male's cage.

6. Room temperature during the quarantine and exposure periods will be maintained at 75±3°F and relative humidity at 50±15%. These measurements will be recorded at least twice daily.



RAM	PORT 1	PORT 2	PORT 3
1	Not Used	75 mg/m^3	*37 mg/m^3
2	Room	10 mg/m^3	37 mg/m^3
3	0 mg/m^3	*1.0 mg/m^3	*0.1 mg/m^3

*** Monitored for calibration procedures only.**

Figure 5. Schematic of the Exposure Chamber Concentration Monitoring System.

STANDARD OPERATING PROCEDURES FOR DEVELOPMENTAL TOXICOLOGY STUDIES

DEVELOPMENTAL TOXICOLOGY

ØB-DT-3BØ3	Cage Location Maps and Daily Observations
ØB-DT-3BØB	Randomization of Animals
ØB-DT-3BØD	Rodent Mating Procedures
ØB-DT-3BØF	Necropsies of Dead or Moribund Animals
ØB-DT-3BØG	Developmental Evaluations for Teratology Studies
ØB-DT-3BØI	Examination of Fetal Heads Fixed in Bouin's Solution
ØB-DT-3BØY	Examination of Double-Stained Fetal Rat and Mouse Skeletons
ØB-DT-3FØ2	Shipping Developmental Toxicology Materials
ØB-HI-3GØ9	Operation of Sealer
ØS-SI-5EØ2	Macintosh Weighing Programs
ØS-SI-3EØ3	Data Transfer from Macintosh to VAX Using MacTerminal

ANIMAL FACILITIES

ØB-AR-3BØ3	Handling and Changing Out Exposure Chambers and Cage Units
ØB-AR-3BØ8	Handling Escaped Small Animals
ØB-AR-3BØG	Barrier Procedures for LSL-II Animal Facility
ØB-AR-3B1R	Pathogen Monitoring
ØB-AR-3B1S	Monitoring for Bacterial Contamination in Animal Drinking Water
ØB-AR-3FØ2	Pre-Exposure Health Screening of Rodents
ØB-AR-3FØ3	Quarantine of Animals
ØB-AR-3FØ5	Management of Animal Feed
ØB-AR-3FØA	Daily Care of Bioassay Animals and Cleaning of Exposure Rooms
ØB-AR-3FØF	Rodent Identification by Tail Tattooing
ØB-AR-3GØ1	Pre-Cleaning Equipment and Operation of Cage-Bottle and Rack Washers
ØB-AR-3GØH	Rodent Weighing using Toledo 8142 Automatic System
ØB-AR-3HØ1	Bi-Weekly Deep Cleaning of Exposure Rooms and Occupied Animal Rooms

INHALATION EXPOSURE AND BIOENGINEERING

ØB-BE-3B1X	Relative Humidity Determination Via Use of Dewpoint Hygrometer
ØB-BE-3B24	Inhalation Exposure Chamber Balance
ØB-BE-3B3H	Build-up and Decay and Overnight Concentration Monitoring
ØB-BE-3B3L	Operation and Calibration of the RAM Sampling System For Aerosol Studies
ØB-BE-3B3Z	Gallium Arsenide IRT Exposure System Daily Operating Procedure
ØB-BE-3CØJ	EG&G Hygrometer: Operation, Maintenance, and Calibration
ØB-BE-3CØL	RTD Thermometer Calibration
ØB-BE-3CØV	Calibration and Check of Chamber Airflow Using Digital Anemometer
ØB-BE-3DØ6	Chamber Leak Test
ØB-BE-3DØE	Exposure Suite QC, Maintenance, and Calibration
ØB-BE-3DØW	Gallium Arsenide Exposure System QC, Maintainance and Calibration
ØB-BE-3EØB	Exposure Suite Data Analysis Program Operation
ØB-BE-3EØE	Exposure Suite Data Editing Program Operation
ØB-BE-3GØ4	Exposure Suite Routine Computer Operation
ØB-BE-3HØ1	Chamber Changeout and Cleaning Procedures for Aerosol Studies
ØB-BE-3SØ7	Aerosol Exposure Suite Entry and Exit Procedure

ANALYTICAL CHEMISTRY

ØB-AC-3A1R	Bulk Analysis of Gallium Arsenide
ØB-AC-3A1S	Gallium Arsenide: Analysis of Building Exhaust
ØB-AC-3C15	Gallium Arsenide: Calibration of Chamber Monitor

SAFETY

ØB-HS-3S19	The 3M Brand W-2860 Hardcap, Continuous-Flow Air Line Respirator
ØB-HS-3S1A	Scott Presur-Pak II Self-contained Breathing Apparatus
ØB-HS-3S1B	Bioassay Studies: Respiratory Protection Program
ØB-HS-3S1C	Bioassay Studies: Health and Safety Plan
ØB-HS-3S21	Biohazard Protocol - Gallium Arsenide
ØB-HS-3S2J	Procedures for the Use of the Glove Box When Generating Aerosols for Inhalation Studies
ØB-HS-3S2K	MSA Ultraview Duo-Flow Supplied Air Respirator
ØB-HS-3S2L	Engineering and Administrative Controls in the Aerosol Complex

NTP PROJECT OFFICE

ØB-QA-3EØA	Filling Out Data Sheets
ØB-9A-3EØ6	Data Handling and Storage of NTP Study Documents and Materials

INHALATION EXPOSURE SYSTEM DESCRIPTION

INHALATION EXPOSURE SYSTEM DESCRIPTION

I. ANIMAL EXPOSURE CHAMBER

The animals will be exposed and maintained in inhalation exposure chambers developed at BNW (U.S. Patent No. 4,261,741, August 12, 1980; Moss, 1980; Brown and Moss, 1981; Moss *et al.*, 1982) and now commercially produced by the Harford Division of Lab Products, Inc., Aberdeen, MD. The chamber (Figure 1) facilitates multiple-tier exposures of various laboratory rodent species to aerosol- and vapor-laden atmospheres. The total volume of the chamber is 2.3 m^3 with an active mixing volume of 1.7 m^3, the remainder being the inlet and exhaust volumes where animals are not placed. There are three levels of caging, each level split into two tiers which are offset from each other and from the chamber walls (Figure 1). Drawer-like stainless steel cage units composed of individual animal cages are suspended in the space above each tier. Stainless steel catch pans for the collection of urine and feces are suspended below each cage unit. Catch pans are left in position during each exposure period.

The chamber is designed so that uniform aerosol or vapor concentrations can be maintained throughout the chamber when the catch pans are left in position. Incoming air containing a uniform mixture of test material is diverted so that it flows vertically along the inner surfaces of the chamber. Eddies are formed (Figure 1) at each tier as the aerosol or vapor flows past the catch pans. Stagnant zones that would normally exist above each pair of catch pans are cleared by exhaust flow through the space between the tiers. Aerosol or vapor reaching the lowest level is deflected across the bottom tiers by metal strips in the space between the catch pan and the wall. Tests have shown that aerosol or vapor concentration homogeneous to within 8% throughout the chamber can be obtained repeatedly provided the aerosol or vapor is uniformly mixed before passing through the chamber inlet (Griffis *et al.* 1981).

II. EXPOSURE SUITE SYSTEM DESCRIPTION

The exposures will be conducted using an automated data acquisition and control system in an exposure suite (Figure 2) consisting of three exposure rooms, a dose preparation room, and a Suite Control Center room (only one of the exposure rooms will be used for this study). Note that concurrent rat and mouse studies will be run in the same chambers. A central computer monitors the basic chamber functions (i.e., test chemical concentration, air flow, vacuum, temperature, and relative humidity) in each of the three exposure rooms. The executive computer is a Hewlett-Packard (HP) Model 9816. All data acquisition and system control originates from this computer.

All experimental protocols related to the data acquisition and control system (such as data channel assignments, monitoring frequencies and alarm settings) reside in the executive computer and are entered into tables accessed by menus.

Data input to the executive computer is accomplished through several interface instruments. All on-line chemical monitor data are collected and preconditioned by HP-85B computers, one for each of the exposure rooms. Conditioned data are transferred to the executive computer for analysis, concentration control, data storage, and printing. Data from all monitoring equipment other than chemical monitors are inputted through a Colorado Data Systems (CDS) Model 53A-IBX Intelligent Interface System (IIS).

System control is provided from the computer by means of control relays in the CDS IIS. These relays control such devices as valves, drive motors, audible alarms, indicator lamps, etc.

Data and comments from each exposure room are stored on separate magnetic diskettes by HP Model 9121 micro-floppy disk drives. Data and comments from each exposure room are printed on separate thermal dot matrix printers (HP Model 2671G). Data are printed and stored immediately upon completion of the measurement to the "Daily Log". At the end of the day (24-hour period), the daily data are analyzed and a summary is printed. This summary includes the the mean, standard deviation, % relative standard deviation, maximum, minimum, and number of measurements for each set of data for the 24-hour period. A second printout provides a table of outliers (i.e., all data points which are beyond the critical limits defined in the protocol). This outlier table allows rapid determination of problem areas in the data. A third printout lists all of the comments which were made to the "Daily Log" over the 24-hour period by either the operator or the computer. This allows rapid inspection of generation start and stop times and any problem areas.

A complete description of the software for this system is contained in BNW document ØB-BE-5EØ1. Maintenance of this system is detailed in SOP # ØB-BE-3DØE. The routine operation of the system software and hardware is detailed in SOP # ØB-BE-3GØ4.

III. AEROSOL GENERATION AND MONITORING

A. Aerosol Generation and Delivery System

The gallium arsenide aerosol generation and delivery system (Figures 3 and 4) is composed of five basic components; a Battelle-designed flexible brush dust feed mechanism, a Trost Model GEM-T air jet mill, a cyclone separator, an aerosol charge neutralizer, and an aerosol distribution system. Each component is discussed in detail below. Routine operation of the generation system is detailed in SOP# ØB-BE-3B3Z. Maintenance and QC procedures are detailed in SOP# ØB-BE-3D12.

1. Flexible Brush Dust Feed Mechanism

The flexible brush dust feed mechanism employs a hopper into which the dry powder is poured. This hopper encloses a randomly wound large bristle brush which continually rotates and stirs the powder and also delivers it through a small hole in the bottom of the hopper into a feed tube. The feed tube which is below and at a right angle to the hopper contains a spiral wound feed brush. The dust is conveyed through the feed tube at a controlled rate by a stepping motor connected to the feed brush. The dust drops from the end of the feed tube and is aspirated into the Trost air-impact pulverizer. At regular intervals throughout the exposure it is necessary to reload the hopper with additional material. The performance of the generation system and the stability of the chamber concentrations is highly dependant upon the loading of the hopper and upon the "free-flow" properties of the gallium arsenide dust. Material for each day is stored overnight in a nitrogen purged desiccator to achieve more uniform behavior of the material in the generator.

2. Trost Air Impact Mill

The Trost air-impact pulverizer (or air mill) uses the fluid energy from opposing air jets to cause particle-to-particle, head-on impaction to deagglomerate and reduce the size distribution of the feed material. Following impaction, particles are swept into a classification chamber where smaller ones exit to the next component of the generation system and the larger ones are thrown to the perimeter by centrifugal force. These larger particles are re-entrained into the air-impacting jets until they are sufficiently reduced in size. Because of the hardness of the gallium arsenide test material, we believe that little size reduction is actually occurring in the air mill, but rather only deagglomeration of the particle fed from the flexible dust feeder.

3. Cyclone Separator

The size distribution of the bulk material, if it were dispersed as supplied, is such that the mass median aerodynamic diameter (MMAD) would be beyond the limits prescribed by the NTP Statement of Work. As pointed out above, the Trost mill is not expected to provide a significant amount of size reduction. Therefore, a significant fraction of the test material must be removed to achieve the appropriate MMAD. Failure to remove the oversized particles would result in clogging of many portions of the distribution system. For these reasons, a cyclone separator is included in the system. A removable cup at the base of the device collects the oversized material for proper disposal.

4. Charge Neutralizer

The actions of the flexible brush dust feeder, the Trost mill, and the cyclone tend to place an excess static charge on the aerosol particles. (The Trost mill is especially effective at charging the particles.) The presence of excess static charge on the particles causes them to be attracted to the walls of the delivery system resulting in reduced efficiency. It may also result in altered deposition patterns within the respiratory tracts of the exposed animals. To control the excess charge, the aerosol is passed through a piece of plastic duct which has two 10 mCi ^{63}Ni-plated foils suspended in the center. The diameter of the duct and the activity of the foils are matched to provide sufficient time for the aerosol to reach Boltzmann equilibrium at the system flow rate.

5. Aerosol Distribution System

The aerosol which exits the charge neutralizer is conveyed across the hall from the Suite Control Center into the exposure room by the aerosol distribution line (Figure 3). At each chamber location, an Air-Vac® pump siphons material from the distribution line into the chamber inlet. The 75, 37 and 10 mg/m^3 exposure chambers are all connected to the primary distribution line. Additional HEPA and charcoal filtered dilution air in the secondary distribution line reduces the aerosol concentration for the lower concentration chambers. (The lower concentration chambers will be used for calibration purposes only.) Each distribution line is terminated with a HEPA filter to remove any excess material not used by the exposure chambers.

B. Monitoring System Description

Monitoring of gallium arsenide aerosol will be accomplished with RAM-1 aerosol monitors. These devices use a pulsed light-emitting diode in combination with a silicon detector to sense the light scattered over a forward angle of 45° to 95° by the particles traversing the sensing volume. The instrument will respond to particles in the 0.1 to 20 µm diameter size range.

A schematic of the chamber concentration monitoring system is shown in Figure 5. The sample system will use a valve to multiplex one RAM-1 monitor to two exposure chambers and either the control chamber or the room. Using one monitor for several chambers is superior to using a single detector for each chamber because of the ease of maintaining and assuring the calibration of a limited number of monitors. This arrangement will also provide three calibration sources for each RAM; two exposure concentrations and a zero point. The monitors will be connected to the chambers through sample lines designed to minimize aerosol particle losses due to settling or impaction. Devices which tend to alter the concentration of the aerosol before it reaches the monitor will be kept to a minimum. The output of the RAM-1 monitors will be automatically read and recorded by the Automated Data Acquisition and Control System. A Hewlett-Packard HP85B computer will remotely control the selection of the correct sample stream and the acquisition of data from the monitor. The equations of the calibration curves will be contained in the HP85B and will be applied to the data obtained from the RAM monitors. Each value obtained will be compared with limit values for the particular location. If a value is beyond control limits, the

HP85B computer will immediately send the information to the executive computer which will take appropriate action.

Daily operating procedures for the RAM-1 aerosol monitoring systems are contained in SOP# ØB-BE-3B3L.

The RAM aerosol monitors will be calibrated against chemical specific analysis of chamber grab samples using Graphite Furnace Atomic Absorption Spectrophotometry (GFAAS). RAM voltages readings will be obtained concurrently with grab samples.

For each RAM, a calibration curve of best-fit will be derived. For the range of concentrations, we will use second-order polynomials to calibrate the instruments.

There is no on-line standard for gallium arsenide aerosol. Routine filter paper samples will be analyzed gravimetrically as a check of the chemical specific RAM calibration. If a discrepancy in the RAM calibration is suspected, additional samples will be obtained and, if necessary, the RAM will be recalibrated.

Prior to the start of each exposure, the presence of a proper zero reading will be verified for each sampling port for each RAM. Proper operation of the RAM-1 monitors throughout each exposure day will be further aided by monitoring either the room or the control chamber with each instrument. If a change in the zero output is detected, the monitor will be serviced or recalibrated if necessary.

Chamber monitor calibration procedures are contained in SOP #ØB-AC-3C19.

The uniform distribution of the test chemical in the chamber was demonstrated in the repeated dose and subchronic studies. Chamber uniformity measurements will be checked after the start of the study (SOP #ØB-BE-3B24 and ØB-BE-3B3H).

C. Aerosol Exposure Complex Safety Procedures

Because gallium arsenide is virtually insoluble in water, consideration has been given to the conduct of exposures, exposure room entry procedures, exposure chamber and room cleaning procedures, and solid waste disposal. Engineering controls, safe work practices, and personnel protective devices have been implemented to ensure maximal personnel protection and minimal potential for the spread of gallium arsenide dust throughout the work environment.

1. Safety Considerations

a. Engineering and Administrative Controls

(1) Aerosol Exposure Complex

To help prevent the spread of the particulate test article, the exposure study will be conducted in Room 404 of the Aerosol Exposure Complex which is comprised of rooms 303, 311, 404, 408, and 412 (Figure 6). The rooms associated with the generation of gallium arsenide have been divided into zones by clear plastic curtains or permanent doorways as follows:

Zone A	-	Clean Corridor
Zone B	-	Entry Zone to Exposure Rooms (404, 408, & 412) and Room 311
Zone C	-	Control Chamber Zone
Zone D	-	Exposure Chamber Zone
Zone E	-	Decontamination Zone
Zone F	-	Step-off Area
Zone G	-	Regulated Corridor

Each zone is described in detail below.

A permanent doorway, similar to those on the exposure rooms, has been installed at the end of the clean corridor (Zone A), effectively separating the Aerosol Exposure Complex from the rest of the clean corridor system. Since the affected rooms are the last rooms on the Clean Corridor, the doorway will create an entry area (Zone B) for the aerosol exposure and decontamination rooms of the Aerosol Exposure Complex. No rooms other than those in the complex will be accessed through this partitioned area.

The exposure room, room 404, dedicated to the gallium arsenide study has been divided into two zones by a plastic curtain. Zone C will be kept as clean as possible. The area designated C in Figure 6 will contain the control chambers and electronic interface equipment and any other equipment which must be maintained in an uncontaminated condition. Chambers containing aerosol of the test material will be located in Zone D. An area in Zone D is designated for washing chambers, catchpans, and other equipment before it is removed from the exposure room via the decontamination area, Zone E. Details of washdown and equipment and personnel movement are described below.

Room 303 has been divided into zones by plastic curtains, walls, and permanent doors. Zone E will be used for the complete decontamination of chambers, caging, catchpans, and other equipment used for non-soluble dust studies prior to their removal to the regulated corridor. Zone F will be maintained as clean as possible and act as a step-off or exit area from the exposure complex into Zone G, the regulated corridor.

Solid contaminated waste, such as excess food will be singly bagged in Zone D then carried through Zone B to be stored in an interim waste container in Zone E until it can be double bagged and placed in a 55-gallon waste drum for later burial at a licensed hazardous waste dump.

Airflow in the exposure complex will be maintained in the direction from least contaminated to most contaminated zones as shown in Figure 6. We have demonstrated that proper air flows between rooms and within rooms can be maintained by correct adjustment of building air balance. The doors from the exposure rooms to the regulated corridor will be sealed except for use as emergency exits.

The dry dispersed aerosol of gallium arsenide will be generated using a flexible-brush dust feed mechanism. All of the generation equipment is contained within a ventilated, HEPA-filtered glovebox with an airlock passthrough located in the Suite Control Center, room 307 (Figure 6). Standard operating procedure BNW SOP #ØB-HS-3S2J discusses the use of the glove box when generating aerosols for inhalation studies.

Standard operating procedure BNW # ØB-HS-3S2L further discusses engineering and administrative controls in the Aerosol Complex.

The aerosol will be delivered from the generation system to the exposure chambers using a distribution line system. This will allow one generation system to provide aerosol to several chambers, thereby reducing the number of generators requiring adjustment, control, and

maintenance. It also allows the the generation systems to be located in the Suite Control Center for easier access by the exposure operator and reduces unnecessary traffic through the animal exposure rooms.

The distribution line will be maintained under negative pressure by the use of Air-Vac pumps attached at the end of the main duct and at the aerosol injection points near the exposure chamber inlets. The distribution system will consist of threaded or compression-fitted plumbing to eliminate the possibility of aerosol escaping from leaks. A HEPA filter at the end of each distribution duct and each chamber exhaust duct will remove all particles from the air before it is exhausted from the room to the building exhaust ventilation system.

(2) Exit Procedures for Personnel

Prior to exiting the exposure room (room 404), personnel will inspect their personal protective equipment and clothing for degree of contamination. If needed, gross contamination of equipment and clothing will be removed by wiping with damp towels. Personnel will then pass through Zone B and enter the decontamination room (Zone E). Outer protective clothing (see below) will be removed in Zone E and placed in the interim waste container. The supplied-air respirators will be removed last and cleaned using Mikro-Quat® solution, clear water rinses, and alcohol-treated wipes for sanitization. Prior to proceeding through the shower, the individual will remove all inner protective clothing (cotton coveralls and head cover, tennis shoes, socks, and underclothing) and place them in a plastic bag for transport to the change room laundry bins. Upon exiting the shower, the person will don fresh inner protective clothing. The person can then safely pass from the Exit Zone (Zone F) into the Regulated Corridor. Details of the entry and exit procedures are covered in BNW SOP# ØB-BE-3SØ7.

(3) Cleaning Procedures

Detailed procedures for chamber changeout and cleaning are covered in BNW SOP #ØB-BE-3HØ1.

Floors and equipment in the exposure room will become contaminated with gallium arsenide during the course of animal observation and chamber cleanup procedures. In order to minimize contamination and the potential for cross contamination to other areas in the facility, the procedures described below will be followed.

Catchpans will be removed and replaced with clean pans during the morning animal observation and care procedures. To reduce the amount of contaminated solid waste, no cageboards will be used in the catchpans. However, clean catchpans will be inserted in the chambers during the morning animal observation period. Observation and cleaning will proceed from the control, through the intermediate, to the high level chamber. Each chamber will be closed before the next chamber is opened, a procedure designed to help prevent the cross contamination of chambers.

Dirty catchpans will be removed from the chambers , wiped with damp paper towels and placed in a catch basin for thorough washing with 250 ppm Mikro-Quat, followed by a clear water rinse.

All chambers will be cleaned once during the developmental toxcicity study. Animals will be transferred to a clean chamber. Chamber changeout will begin from the control chambers and proceed through the intermediate to the high concentration chambers. The catchpans will be removed from the dirty chamber and cleaned as described above. A slide valve on the inlet duct of the exposure chamber will then be closed to limit the escape of collected gallium arsenide dust. The exposure chamber will then be removed from the system and the clean chamber, with animals, attached in its place. The doors of the clean chamber will then be secured and the slide valve re-opened. The dirty chamber, with the caging in place, will be moved to the wash area of

the exposure room and washed. Cleaning will consist of misting with Triton-X solution followed by a high pressure wash and clear water rinse. The efficacy of cleaning procedures has been tested during a similar study (gallium arsenide) by collecting swipe samples for analysis by the Hanford Environmental Health Foundation. The results of swipe sampling performed during other studies involving identical handling procedures and safeguards have demonstrated that our cleaning methods are sufficient to reduce the level of contamination from values of in excess of 1.5 mg/in^2 (predicted) to ~0.6 µg/in^2.

(4) Other Administrative Controls

Workers performing duties in the test chemical exposure room are required to use MSA full-face, positive flow, supplied-air respirators at all times. Entry to the aerosol exposure room is strictly controlled and access is limited specifically to those staff assigned to work on the gallium arsenide study.

b. Protective Apparel and Equipment

All personnel who might be exposed to test material or exposed animals will use appropriate protective clothing and equipment. Those individuals entering the Dust Exposure Complex are required to wear, in addition to supplied cotton coveralls and sneaker shoes; outer disposable Tyvek® or KleenGuard® coveralls, rubber shoe covers, neoprene gloves over latex, disposable Saranex® head shroud, and MSA full-face, supplied-air respirator. All cuffs must be sealed with tape to prevent contact of gallium arsenide with bare skin. Prior to exiting the exposure room complex, the respirator, overshoes, gloves, and coveralls are removed and discarded or cleaned and stored as appropriate to the particular piece of protective equipment. Disposable protective clothing will not be worn outside the bioassay work areas.

Supplied-air respirators - - in addition to other protective clothing - - will be worn by personnel working in those other areas in which these compounds are present at levels that require such precautions.

2. Miscellaneous

In the event of a spill of dry, bulk powdered gallium arsenide, the chemical will be vacuumed from the contaminated surface using a dedicated HEPA-filtered vacuum cleaner. The surface will then be cleaned using Triton-X solution, followed by clear water rinsing. Smear samples may then be taken to determine the efficiency of the surface cleaning procedures.

The test chemical for daily use will be stored in a chemical storage cabinet within Room 311. This room is equipped with a fume hood, sink, and plumbed-in eyewash fountain.

The animal weighing scales will be dedicated to the gallium arsenide study and will be kept within the exposure room. Communication with the Xybion terminal will take place by way of plugs mounted through the exposure room wall. The Xybion terminal will be located outside of the exposure room (in the regulated corridor) to reduce the possibility of contamination.

When it becomes necessary to remove piping associated with delivery of gallium arsenide aerosol to the exposure chambers at the termination of the study, techniques developed for the removal of asbestos-insulated piping will be used. These techniques include the use of glove bags to encase the piping prior to disassembly. Those items will be included in the inventory of waste materials to be disposed of at the licensed hazardous waste facility.

IV. CHAMBER ENVIRONMENTAL CONTROL AND MONITORING

A. Temperature

Nearly all of the heat load contributed to the exposure chamber by the animals is dissipated from the chamber by radiation through the chamber wall (Bernstein and Drew, 1980). Temperature of the air supplied to the chamber has little effect on the temperature of the chamber. On the other hand, temperature of the room housing the the chamber has a great deal of effect. Consequently, chamber temperature is maintained in the proper range primarily by controlling the room temperature.

Temperatures of the exposure chambers and exposure room are measured by Resistance Temperature Detectors (RTDs). The RTDs are placed in a representative location in each chamber (a top sample port on the back side). Each RTD is connected to an Omega Model 412B Digital Thermometer by either a manual select switch or by computer controlled scanner relays. This allows the temperature to be read manually or to be recorded automatically by the exposure system executive computer. Temperatures are automatically recorded at regular intervals during each 24-hour day. All temperature measurement equipment except the RTDs is located in the Exposure Suite Control Center. RTDs are calibrated to within 0.5°F of a certified mercury thermometer (SOP # ØB-BE-3CØL) before the start of each study.

B. Relative Humidity

Relative humidity (RH) in the exposure chambers is controlled by the system depicted in Figure 7. Equipment located in the RH Control Equipment Room (Room 335 of the LSL-II basement) provides separate ducts of dry and moist air to each exposure chamber. Filtered air with a maximum dewpoint of about 53°F is supplied to the RH Control Equipment by the building HVAC system. This air is evenly delivered to two ducts. Air from the first duct passes into a plenum where steam, generated from city tap water with no additional additives, is injected to bring the air to a dewpoint of about 60°F. This provides the moist air source for the chambers. The air from the second duct passed through a refrigeration coil which reduces the moisture content of the air to a dewpoint of about 40°F. This provides the source of "dry" air for the chambers. A manually controlled mixing valve for each chamber mixes the proper proportions of the moist and dry air to maintain the proper RH in each chamber. The mixing valve can also be controlled by the computer providing automatic control of chamber RH.

Relative Humidity is measured using an EG&G Model 910 dewpoint hygrometer located in the Exposure Suite Control Center. Air from the exposure chambers is sampled from a representative location (a top port on the back side). A teflon filter is placed at the chamber end of the sample line if the test article is an aerosol. Samples of the air from each measurement location are continuously pulled through polytetrafluoroethylene (PTFE) tubing to a central location in the Exposure Suite Control Center. This assures a fresh sample at the dewpoint hygrometer. Sample air from a particular location is routed by a multiplexed valve system to either the exposure system exhaust or the dewpoint hygrometer for RH determination. The valves are controlled by either a manual switch or by a computer controlled relay. This allows RH to be measured manually or automatically by the exposure system executive computer. RH is automatically recorded at regular intervals during the 24-hour day.

Once the dewpoint has been determined by the hygrometer, the RH is automatically calculated by the exposure system executive computer using the dewpoint value and the temperature (measured simultaneously at the same location by the RTD system). The following equation is used for this calculation:

$$\%RH = \frac{10^{\left[9.91 - \frac{2714.55}{(5/9)(T_1 - 32) + 293.3}\right]}}{10^{\left[9.91 - \frac{2714.55}{(5/9)(T_2 - 32) + 293.3}\right]}} \times 100$$

Where: T_1 = dewpoint temperature (°F)
T_2 = drybulb temperature (°F)

Calibration of the dewpoint hygrometer is established prior to the start of the study following SOP # ØB-BE-3B1X. Initial calibration requires comparison at three RH levels (≈ 30%, 50% and 70%) of the RH calculated by the monitor to measurements made by a calibrated portable hygrometer and RTD located near the chamber.

C. Chamber Air Flow

Air flow in the chambers is maintained by the vacuum in the central chamber exhaust duct. This vacuum is created by the chamber exhaust flow fans located in the South Equipment Room of the LSL-II Building. There are two parallel exhaust fans, one operating at a time with the other providing backup. Both fans operate from emergency power.

Chamber air flow rate is controlled by a gate valve in each individual chamber exhaust duct. A drive motor attached to the stem of this valve, allows the control of chamber flow either by computer or manually from the Exposure Control Center.

Fine control of exposure concentration can be accomplished by automatically or manually adjusting the valve position to control chamber dilution air flow within the allowable limits. Gross adjustment of concentration must be done manually by adjusting the generation system.

Chamber air flow is measured by a multiplexed orifice-meter system consisting of a calibrated orifice located in each chamber exhaust, a Validyne Model DP-45 pressure transducer, a Validyne Model CD-18 carrier demodulator, and a Validyne Model PM-12 digital voltmeter. The pressure transducer is multiplexed to each chamber's flow orifice by valves remotely controlled either manually or by means of the executive computer. This allows flow to be measured either manually or automatically. Flow is automatically recorded at regular intervals during the 24-hour day.

Calibrated flow orifice meters are located at both the inlet and exhaust to each chamber. By comparing the measured flow at the inlet and exhaust, leaks in the chamber can be detected. A leak check is automatically performed by the executive computer when each chamber is closed. If a leak is detected, the executive computer will notify the operator and will not allow exposures to proceed until the leak is repaired. This system is sensitive to very small leaks which may cause an imbalance of test article concentration within the chamber.

Calibration of the flow orifices will be done before the start of the study following SOP # ØB-BE-3CØV.

D. Chamber Vacuum

The chambers are maintained at a slight negative pressure compared to the room in order to reduce the possibility of escape of test article. This negative pressure is created by the pressure drop across the HEPA and charcoal filters at the inlet to each chamber.

The same Validyne pressure transducer system used to measure chamber flows is used to measure chamber vacuum. Vacuum in the chamber is measured relative to atmospheric pressure in the Suite Control Room. Vacuum is automatically recorded at regular intervals during the 24-hour day.

Vacuum is also continuously monitored by a mechanical pressure switch attached to each chamber. In the event of leak in the chamber, the pressure switch will immediately shut off the flow of test article to the chamber and activate an audio alarm.

V. ANIMAL FACILITY AIR HANDLING SYSTEM

Supply air enters the building through two identical parallel air handling systems (Figure 8). Each system consists of a pre-heat coil, a filter system, a heating coil, a chilling coil, and a supply fan. The pre-heat coil heats the air to a minimum of 45°F. The filter system, comprising a roll filter, pre-filter, and a bag filter, rids the air of most particles. The heating and chilling coils maintain the temperature of the air exiting the air conditioning system at about 53°F. The chilling coils also dry the air to a dewpoint not greater than 53°F.

Although simultaneous operation of both of the parallel air supply systems is necessary to provide the 20 air changes per hour typically supplied to each animal room, only one of these systems, which can be operated from the emergency power system, is required to maintain the rooms within the temperature and flow specifications required by the protocol. Exposure of the animals to the test article can continue in the event of the failure of one of the air supply systems.

The air from the two parallel building air supply systems is mixed together by an air mixing unit and is divided into two ducts which feed the rooms on the east and west sides of the animal quarters. If necessary, steam is injected into the air in these ducts to maintain the relative humidity of all rooms in the basement at a minimum of 35%. In rooms where further room RH control is necessary, it is provided by individual steam generators located in the room. Prior to entering the animal room, the air is filtered through a HEPA filter.

Air for exposure chambers is supplied to a chamber relative humidity conditioning system from the building air supply systems. A single supply system is sufficient to supply air to the RH conditioning systems for all exposure chambers in the facility.

Exhaust from the animal room is filtered by a room HEPA filter and again through a bank of building exhaust HEPA filters assuring no escape of aerosol particles from the facility. Three parallel exhaust fans provide exhaust from the rooms. Two of these fans are in operation with the third as a backup unit. One fan can be operated from the emergency power system in case of power failure.

A separate exhaust duct system for the chambers allows for the addition of scrubbers to remove particles or vapors before exhausting from the building. Because the chamber exhaust system has a separate fan, failure of one of the building exhaust fans will not prevent the continuation of exposures.

VI. EXPOSURE SUITE ALARM SYSTEM

An extensive system of alarms has been incorporated into the exposure suite automated data acquisition and control system to provide safety for the system operators, protect the health of the animals and ensure the integrity of the study. There are actually two separate alarm systems; one provided by the computer and a separate "physical" alarm system which provides redundancy for some of the computer alarm functions.

Following each function measured by the computer, the value is compared to the alarm limit values (stored in the computer memory) for that function . There are four limit values for each function and location monitored by the computer; high and low non-critical and high and low critical. For example, chamber flows may have the following limits:

Critical low .....10 air changes per hour
Non-critical Low 12
Non-critical High.....18
Critical High 20

The result of an alarm condition depends on the function measured and the measurement location. Each function and location has an alarm response assignment in the computer. Again using chamber flow as an example, flows exceeding the non-critical limits but remaining within the critical limits will cause the computer to print a "beyond-non-critical-limits" symbol, "(" if low and ")" if high, next to the data on the daily log printed by the computer. A chamber flow which exceed the critical limits will cause the computer to print a "beyond-critical-limits" symbol, ">" if high and "<" if low, on the daily log and to turn on the critical alarm audio alert. A critical low flow alarm will also shut off the flow of test article to the chamber. Although it is possible or the computer to make automatic corrections to air flow in the chamber, this is not done because to do so would affect concentration of the test article in the chamber. A critical low negative pressure in a chamber (which may be the result of a leak in the chamber) will also cause the computer to shut off the flow of test article to the chamber. Similar responses result from alarms arising from temperature and relative humidity measurements in the chambers, however these alarms have no affect on the operation of the test article generator.

All critical alarms arising from measurements of generator function (such as vaporizer temperature) will result in all functions of the generator being turned off.

The physical alarm system includes the following continuously monitoring devices:

- Chamber pressure (also detects critically low flow if it is the result of pump failure and not a clogged chamber inlet duct)
- Generator cabinet exhaust flow
- Chamber exhaust system flow
- Building exhaust system flow
- Explosive level detectors monitoring the chambers & generator cabinet (present only if test article is flammable).

In all cases an alarm condition from any one of these monitors is considered critical and results in the test article generator being shut off.

VII. CHAMBER EXHAUST WASTE TREATMENT

The exhaust from the exposure chambers is HEPA filtered to remove all particles which may impede the valving system associated with the exhaust duct and to assure no escape of aerosol from the facility. Exhaust from the animal room is also filtered by a room HEPA filter and again through a bank of building exhaust HEPA filters.

All HEPA filters used on the study have been tested for efficiency prior to use by personnel from the Hanford Environmental Health Foundation.

VIII. DATA RECORDING AND HANDLING

Data from each exposure room are stored in the Exposure Suite Control Center on separate magnetic disks by Hewlett-Packard (HP) Model 9121 micro-floppy disc drives. Data and comments from each exposure room are printed by separate thermal dot matrix printers (HP Model 2171G) or by ink jet printers (HP Model 2225A). Data are printed and stored immediately upon completion of the measurement to a Daily Log (example, Figure 9). Both the Daily Log and the disks will be maintained in the study files. The Daily Log will be considered the raw data. The Daily Log includes the time of measurement, the measurement location (such as chamber), the measurement function (such as temperature), the value of the measurement, the percent of target, an alarm code, and a status code. See Figure 9 for an explanation of the alarm and status codes.

At the end of the day (24-hour period), the daily data are analyzed and three summaries are printed. The first (example, Figure 10) includes the mean, % of target, standard deviation, % relative standard deviation, maximum, minimum, and and number of measurements for each function (such as temperature) and location (such as chamber) monitored over the 24-hour period. The second (example, Figure 11) provides a list of outliers; that is, all data points which were beyond the defined critical operating limits. This printout allows for quick review of data which is outside of the operating limits. The final summary (example, Figure 12) is a printout of all comments made by the computer, exposure specialist, and exposure operator during the 24-hour period. This includes comments on startup time, exposure termination, new calibration factors entered and other information. This summary allows a quick review of events that occurred during the day.

Data handling and analysis procedures are describe in SOPs ØB-BE-3EØB and ØB-BE-3EØE.

IX. EQUIPMENT OR POWER FAILURE PROTECTION SYSTEMS

Power is provided to the Battelle complex from two separate city substations through an automatic switching device. This significantly reduces the possibility of losing city power. Power from the city is routed to equipment in the LSL-II building through two types of motor control centers. One type can switch power from the LSL-II diesel generator. The other has access only to city power. The emergency-power-type motor control center has a low voltage detector on each leg of the three-phase input power. If the city supplied power should fail or "brown out", these detectors automatically start the emergency power diesel generator and route the emergency power to the equipment connected to the emergency-power-type motor control center.

All equipment critical to the well-being of the animals is connected to the emergency-power-type motor control center. This equipment includes:

- Emergency lighting and electrical outlets
- Building air conditioning chillers #1 and #2
- Building heating boilers and feedwater pump systems #1 and #2
- Air compressors #1 and #2
- Air supply fans #1 and #2
- Air exhaust fans #1 and #2

Note that there are two identical units of all equipment that is vital to the well-being of the animals (heating, cooling, supply air, exhaust air, and compressed air). Either of the two units has sufficient capacity to maintain the animal environment within a safe range. In all cases, the emergency power system will operate one of the two identical systems.

All building or chamber systems which are essential to the survival of the animals are alarmed. If a system malfunctions, an alarm is tripped in the Power Operator's office. A Power Operator is on duty 24 hours/day, 7 days/week. If the Power Operator is not authorized to correct the problem that caused the alarm, he immediately calls the appropriate personnel of the programs affected.

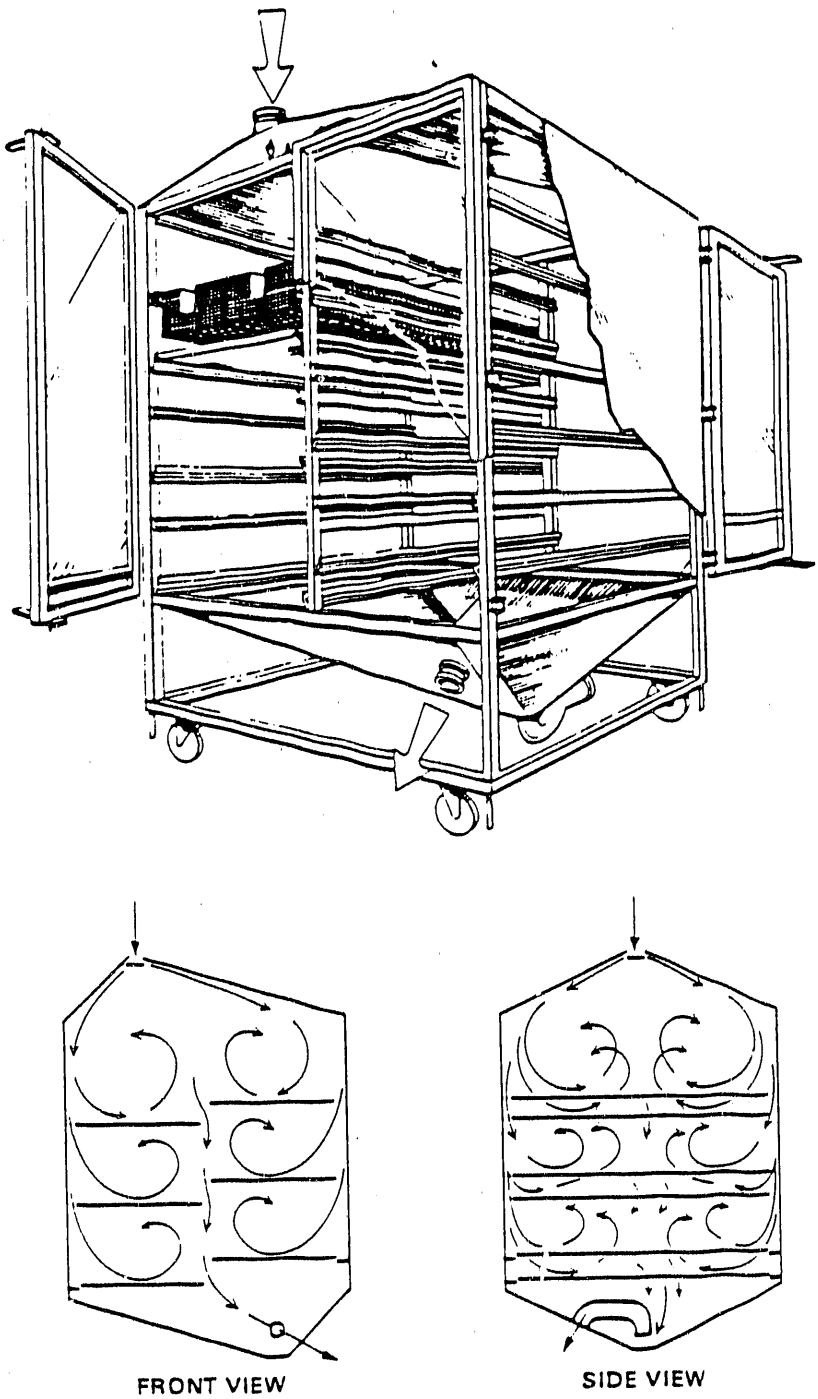


Figure 1. Inhalation Exposure Chamber Designed at BNW.
Top: Oblique Cutaway View of the Chamber;
Bottom: Airflow Patterns.

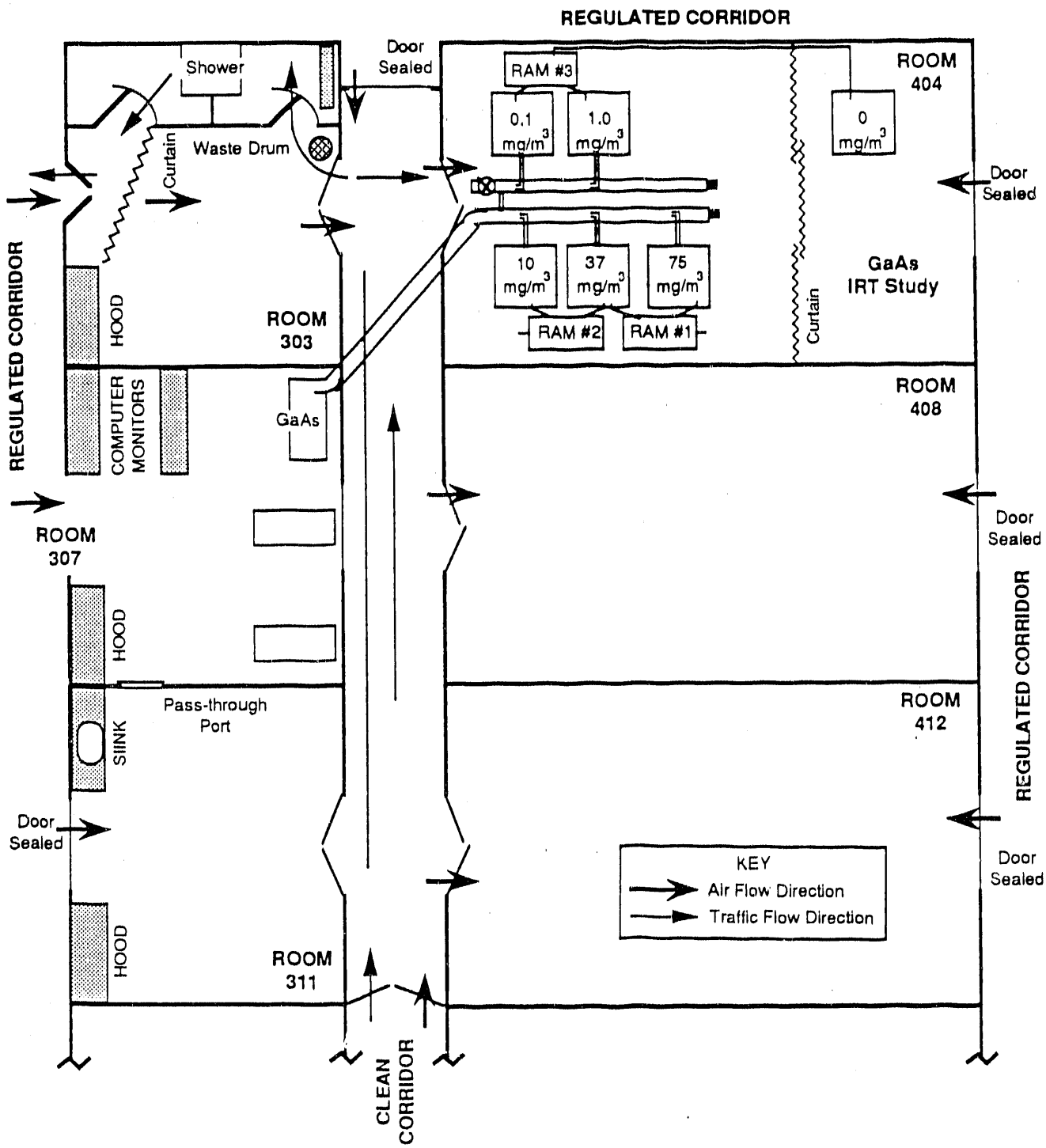


Figure 2. Schematic Diagram of the Gallium Arsenide Exposure Suite.

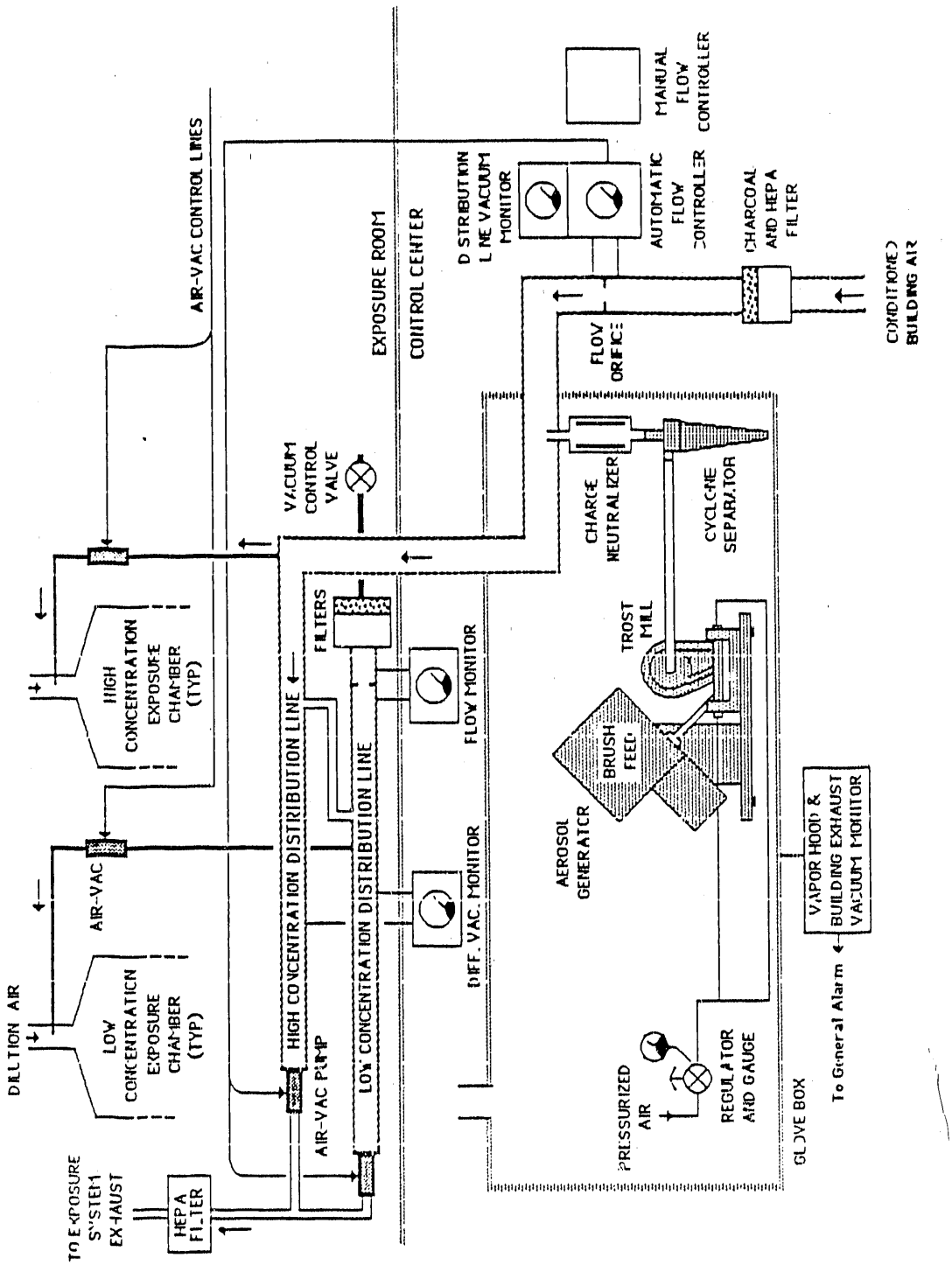


Figure 3. Schematic of Gallium Arsenide Aerosol Generation and Distribution System.

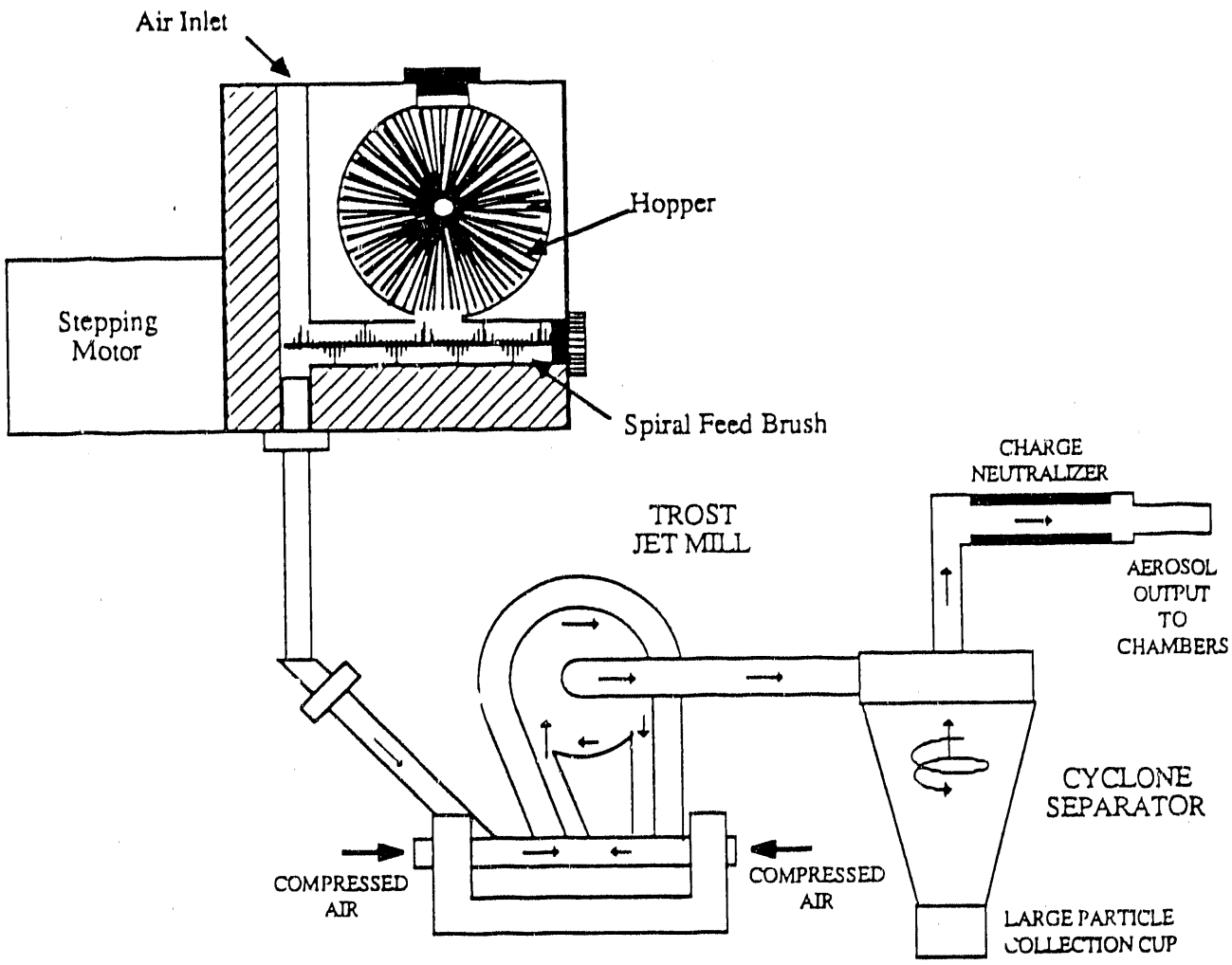
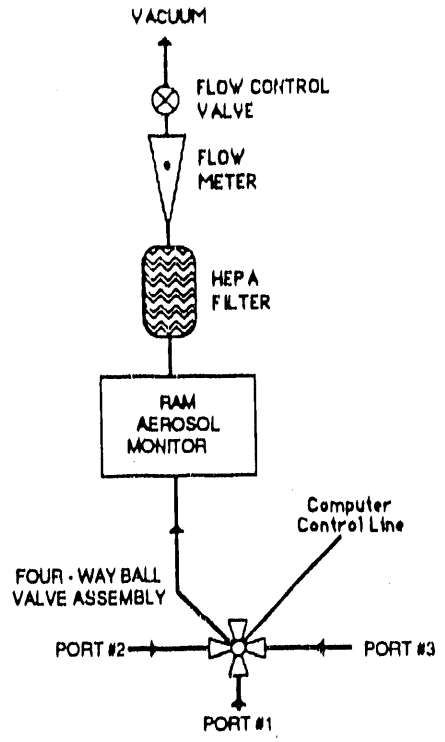


Figure 4. Flexible Brush Dust Feed Mechanism.



PORT

RAM	1	2	3
1	NOT USED	75 mg/m^3	37 mg/m^3
2	Room	10 mg/m^3	37 mg/m^3
3	0 mg/m^3	1.0 * mg/m^3	0.1 mg/m^3

* Concentration data recorded only during animal exposures.

☐ = Monitored for calibration purposes only.

Figure 5. Schematic of the Exposure Chamber Concentration Monitoring System.

New figure 11/28/90 by Amendment C.

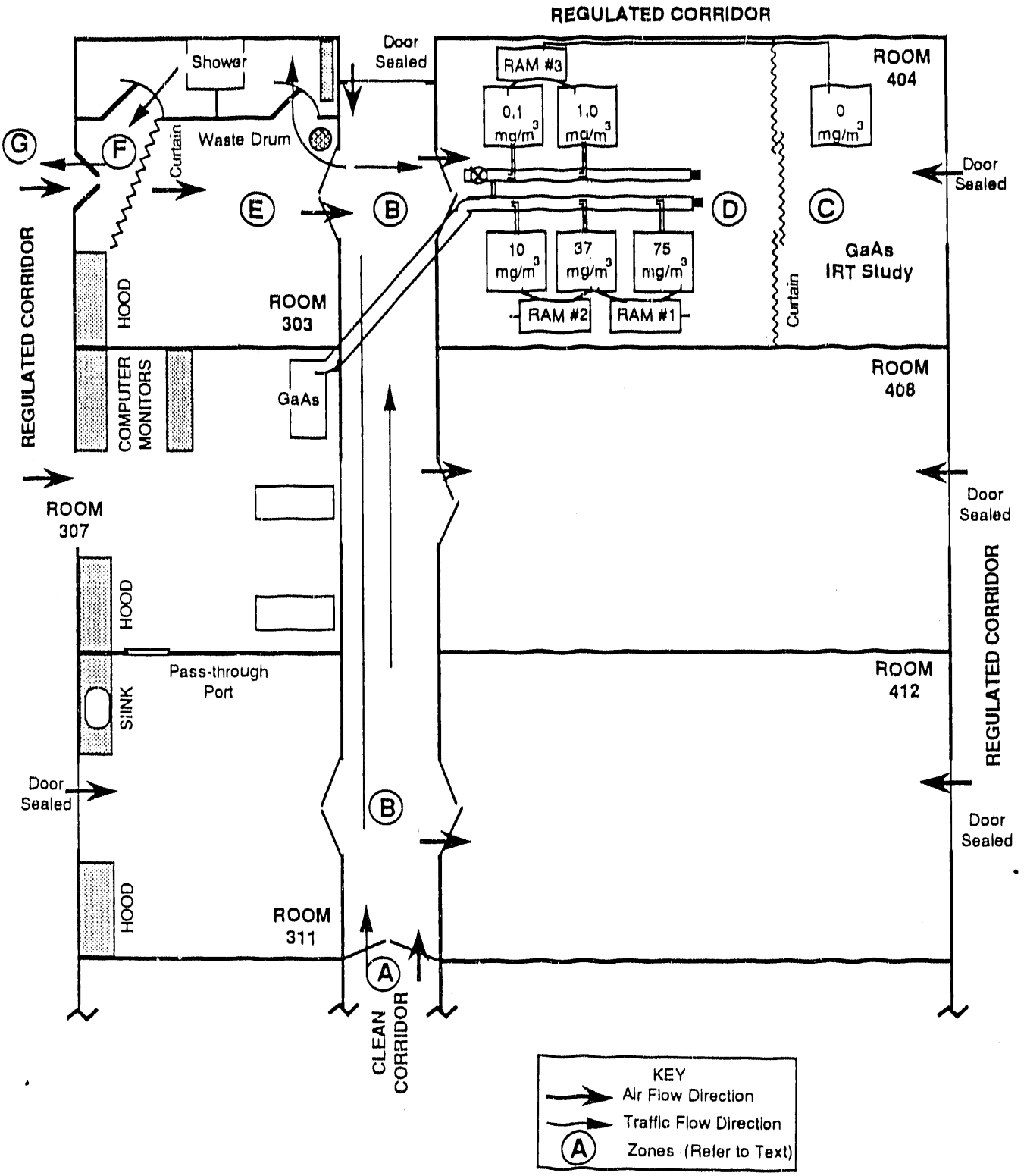


Figure 6. Aerosol Exposure Complex Layout Showing Various Work Zones and the Areas Designated for Entry, Exit, and Decontamination.

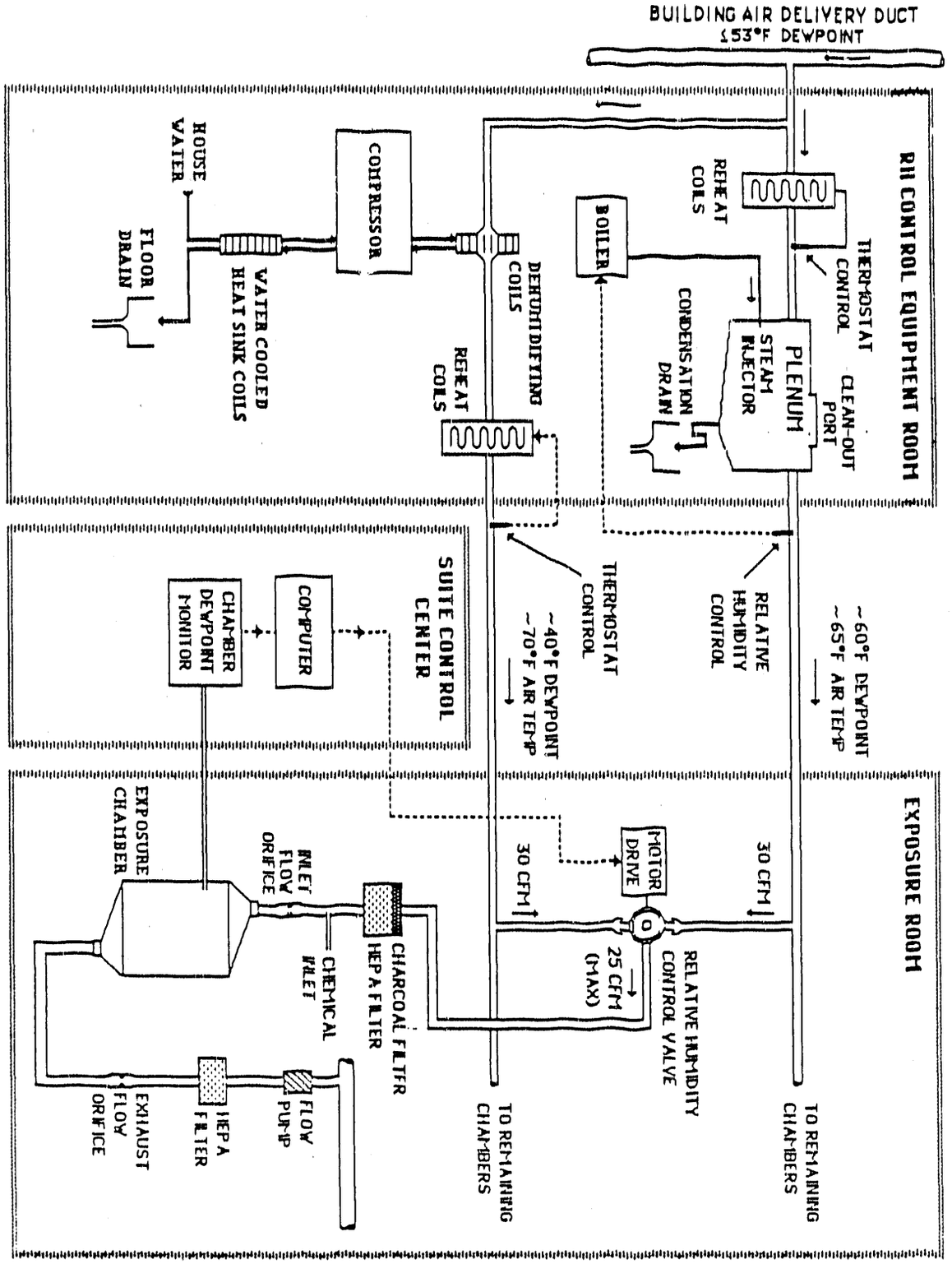


Figure 7. Schematic Diagram of the Chamber Relative Humidity Control System.

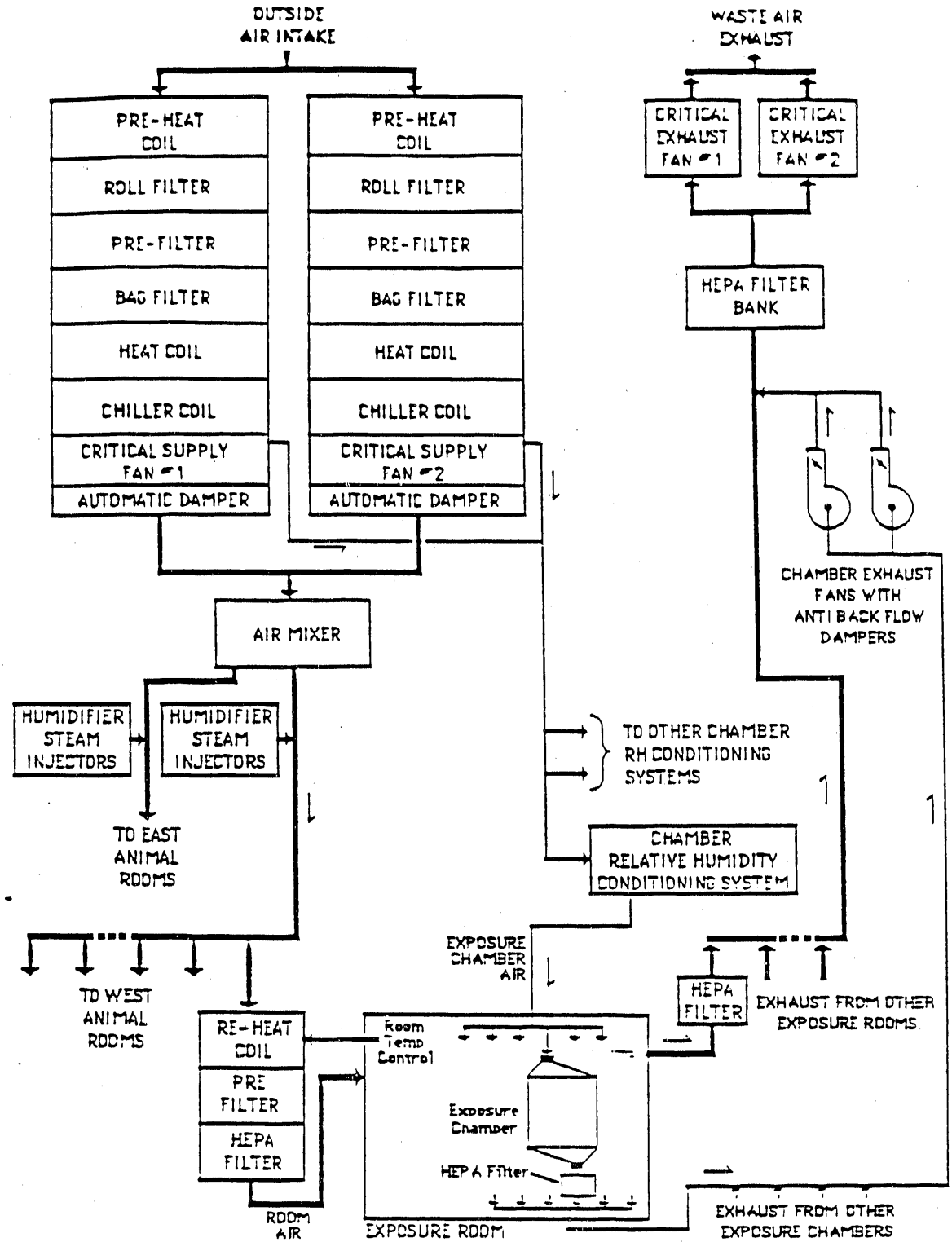


Figure 8. Air Handling System for Animal Rooms of Life Sciences II Building.

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Time	Data Origin	Function	Data	Targt
	[LR] TFE - 625 ppm -R/M -T90 Time Expired-Including Conc Data			
	[LR] TFE - 312 ppm -R/M -T90 Time Expired-Including Conc Data			
	[LR] TFE - 625 ppm -R -T90 Time Expired-Including Conc Data			
	[LR] TFE - 312 ppm -R -T90 Time Expired-Including Conc Data			
	[LR] TFE - 156 ppm -R -T90 Time Expired-Including Conc Data			
08:17	Hewlett Packard 85B (Access Level: Specialist) TFE - 1250 ppm -R/M-Conc Data Excluded-Data Time<T90 & Data<Target			
08:19	Hewlett Packard 85B (Access Level: Specialist) TFE - 625 ppm -R/M-Conc Data Excluded-Data Time<T90 & Data<Target			
08:21	Hewlett Packard 85B (Access Level: Specialist) TFE - 312 ppm -R/M-Conc Data Excluded-Data Time<T90 & Data<Target			
08:29	TFE - 625 ppm -R	Temperature	OKI 74.3 F	99%
08:30	TFE - 1250 ppm -R/M	Temperature	OKI 74.0 F	99%
08:32	TFE - (332) Room	Temperature	OKI 69.3 F	96%
08:34	TFE - (332) Room	Relative Humidity	OKE 53.0 %	106%
08:37	TFE - 0 ppm -R	Relative Humidity	OKI 46.0 %	84%
08:39	TFE - 0 ppm -R/M	Relative Humidity	OKI 47.0 %	85%
08:42	TFE - 156 ppm -R	Relative Humidity	OKI 48.0 %	87%
08:44	TFE - 312 ppm -R/M	Relative Humidity	OKI 49.0 %	89%
08:17	TFE - 1250 ppm -R/M	GC#34-809569	OKE 6.760E+2 ppm	55%
08:19	TFE - 625 ppm -R/M	GC#34-809569	OKE 3.445E+2 ppm	56%
08:21	TFE - 312 ppm -R/M	GC#34-809569	OKE 2.507E+2 ppm	81%
08:24	TFE - 0 ppm -R/M	GC#34-809569	OKI 0.000E+0 ppm	0%
08:26	TFE - (332) Room	GC#34-809569	OKI 0.000E+0 ppm	0%
08:29	TFE - 625 ppm -R	GC#34-809569	OKI 5.874E+2 ppm	94%
08:31	TFE - 312 ppm -R	GC#34-809569	OKI 2.854E+2 ppm	92%
08:34	TFE - 156 ppm -R	GC#34-809569	OKI 1.521E+2 ppm	98%
08:36	TFE - 0 ppm -R	GC#34-809569	OKI 0.000E+0 ppm	0%
08:40	TFE - Standard Gas-L	GC#34-809569	OKE 2.880E+1 ppm	20%
08:43	TFE - Standard Gas-H	GC#34-809569	OKI 4.993E+2 ppm	100%
08:47	TFE - 312 ppm -R	Relative Humidity	OKI 49.0 %	89%
08:49	TFE - 625 ppm -R/M	Relative Humidity	OKI 48.0 %	87%
08:52	TFE - 625 ppm -R	Relative Humidity	OKI 47.0 %	85%
08:54	TFE - 1250 ppm -R/M	Relative Humidity	OKI 53.0 %	96%
08:54	TFE - 0 ppm -R	Exhaust Air Flow	OKI 15.3 CFM	102%
08:55	TFE - 0 ppm -R/M	Exhaust Air Flow	OKI 15.0 CFM	100%
08:55	TFE - 156 ppm -R	Exhaust Air Flow	OKI 14.6 CFM	97%
08:55	TFE - 312 ppm -R/M	Exhaust Air Flow	OKI 14.6 CFM	97%
08:56	TFE - 312 ppm -R	Exhaust Air Flow	OKI 14.6 CFM	97%
08:56	TFE - 625 ppm -R/M	Exhaust Air Flow	OKI 14.9 CFM	99%
08:56	TFE - 625 ppm -R	Exhaust Air Flow	OKI 15.3 CFM	102%
08:56	TFE - 1250 ppm -R/M	Exhaust Air Flow	OKI 14.8 CFM	99%
08:45	TFE - 1250 ppm -R/M	GC#34-809569	OKI 1.212E+3 ppm	97%
08:48	TFE - 625 ppm -R/M	GC#34-809569	(OKI 5.594E+2 ppm	90%
08:50	TFE - 312 ppm -R/M	GC#34-809569	OKI 2.923E+2 ppm	94%
08:53	TFE - 0 ppm -R/M	GC#34-809569	OKI 0.000E+0 ppm	0%

Figure 9. Example of 24-Hour "Daily Log" Printout from Data Acquisition and Control Computer. (See Following Page for Explanation of Columns.)

Figure 9. (continued)

DESCRIPTION OF COMPUTER "DAILY LOG" OUTPUT

The date, exposure name, program version and page number will be printed at the top of each page of the daily log

Column 1: Time -- time that measurement was taken
Column 2: Location -- location of measurement (for example, chamber)
Column 3: Function -- measurement function (for example, temperature)
Column 4: Data --

Alarm Code -- "(" Indicates data < non-critical low but ≥ critical low alarm value
")" Indicates data > non-critical high but ≤ critical high alarm value
"<" Indicates data < critical low alarm value
">" Indicates data > critical high alarm value

Status Code -- "OK" Indicates monitoring instrument is functioning properly and is calibrated
"BS" Indicates service time of monitoring instrument has expired. (Usually indicates that instrument calibration should be checked. Does not necessarily mean that data is not valid)
"I" Indicates data will be included in summary
"E" Indicates data will be excluded from summary

Data Value -- Data may be expressed in scientific notation (x.xxxEyy)

Units Label -- Units of measurement (e.g., ppm, °F, mg/m^3)

Column 5: Percent Target

Summation for the File: Nov_03_88 Exposure: Tetrafluoroethylene-Chronic

Exhaust Air Flow	Mean	% Targ	Std Dev	% RSD	Maximum	Minimum	Num Xs
TFE - 0 ppm -R	15.5	103%	.09	1%	15.6	15.3	8.
TFE - 0 ppm -R/M	15.1	100%	.05	0%	15.1	15.0	8.
TFE - 156 ppm -R	14.6	98%	.03	0%	14.7	14.6	8.
TFE - 312 ppm -R/M	14.6	98%	.03	0%	14.7	14.6	8.
TFE - 312 ppm -R	14.7	98%	.05	0%	14.7	14.6	8.
TFE - 625 ppm -R/M	14.9	100%	.05	0%	15.0	14.9	8.
TFE - 625 ppm -R	15.4	103%	.06	0%	15.5	15.3	8.
TFE - 1250 ppm -R/M	14.9	99%	.08	1%	15.0	14.8	8.

Vacuum	Mean	% Targ	Std Dev	% RSD	Maximum	Minimum	Num Xs
TFE - 0 ppm -R	.9	94%	.04	5%	1.0	.9	9.
TFE - 0 ppm -R/M	1.0	98%	.02	2%	1.0	1.0	9.
TFE - 156 ppm -R	.9	89%	.01	1%	.9	.9	9.
TFE - 312 ppm -R/M	.9	95%	.01	1%	1.0	.9	9.
TFE - 312 ppm -R	.8	79%	.03	4%	.8	.8	9.
TFE - 625 ppm -R/M	.9	90%	.01	1%	.9	.9	9.
TFE - 625 ppm -R	.9	95%	.03	3%	1.0	.9	9.
TFE - 1250 ppm -R/M	1.1	108%	.03	3%	1.1	1.0	9.

Relative Humidity	Mean	% Targ	Std Dev	% RSD	Maximum	Minimum	Num Xs
TFE - 0 ppm -R	49.1	89%	3.09	6%	53.0	45.0	8.
TFE - 0 ppm -R/M	54.6	99%	8.53	16%	65.0	44.0	8.
TFE - 156 ppm -R	51.2	93%	3.28	6%	56.0	47.0	8.
TFE - 312 ppm -R/M	52.9	96%	6.83	13%	60.0	43.0	8.
TFE - 312 ppm -R	55.7	101%	4.68	8%	63.0	49.0	8.
TFE - 625 ppm -R/M	54.5	99%	7.23	13%	62.0	43.0	8.
TFE - 625 ppm -R	52.4	95%	4.69	9%	59.0	46.0	8.
TFE - 1250 ppm -R/M	59.5	108%	8.25	14%	69.0	48.0	8.

Temperature	Mean	% Targ	Std Dev	% RSD	Maximum	Minimum	Num Xs
TFE - (336) Room	69.9	97%	.58	1%	70.6	68.9	9.
TFE - 0 ppm -R	75.5	101%	.72	1%	76.6	74.7	9.
TFE - 0 ppm -R/M	75.0	100%	.76	1%	76.5	73.9	9.
TFE - 156 ppm -R	75.5	101%	.61	1%	76.3	74.7	9.
TFE - 312 ppm -R/M	75.2	100%	.36	0%	76.0	74.7	9.
TFE - 312 ppm -R	75.6	101%	.65	1%	76.4	74.6	9.
TFE - 625 ppm -R/M	76.2	102%	.57	1%	77.0	75.3	9.
TFE - 625 ppm -R	75.1	100%	.67	1%	76.0	74.3	8.
TFE - 1250 ppm -R/M	74.6	100%	.42	1%	75.2	74.0	8.
TFE - (332) Room	69.5	96%	.33	0%	69.9	69.0	8.

GC#34-809569	Mean	% Targ	Std Dev	% RSD	Maximum	Minimum	Num Xs
TFE - (332) Room	0.00E+0	0%	0.000E+0	0%	0.00E+0	0.00E+0	15.
TFE - 0 ppm -R	0.00E+0	0%	0.000E+0	0%	0.00E+0	0.00E+0	15.
TFE - 0 ppm -R/M	0.00E+0	0%	0.000E+0	0%	0.00E+0	0.00E+0	15.
TFE - 156 ppm -R	1.53E+2	98%	2.010E+0	1%	1.56E+2	1.49E+2	13.
TFE - 312 ppm -R/M	3.07E+2	98%	5.478E+0	2%	3.13E+2	2.92E+2	12.
TFE - 312 ppm -R	3.09E+2	99%	1.068E+1	3%	3.21E+2	2.85E+2	13.

Figure 10. Example of 24-Hour "Data Summation" Printout from the Data Acquisition and Control Computer. (Data are organized by data type.)

Outlier Table for the File: Nov_21_88 Exposure: Acetonitrile

Origin	Instrument	Time	Data	Lower	Target	Higher
Aceto - 0 ppm-M	Relative Humidity	10:14	33.0	35.0	55.0	75.0

Figure 11. Example of 24-Hour "Data Outlier Table" Printout from Data Acquisition and Control Computer. (Table shows data which were beyond the defined Critical Limits.)

Daily Comments Tetrafluoroethylene-Chronic File: Nov_03_88

Time	Operator	Comment
07:51		Chamber Leak Check for TFE - 156 ppm -R
07:51		Exhaust Flow= 14.6 Inlet Flow= 15.1 (-3.4% leak) [Acceptable]
07:52		Chamber Leak Check for TFE - 0 ppm -R
07:52		Exhaust Flow= 15.2 Inlet Flow= 15.6 (-2.6% leak) [Acceptable]
07:52		All Chambers have been found ACCEPTABLE.
08:01	Hewlett Packard 85B	TFE - Standard Gas-H-Conc Data Excluded-Exposure Not Running.
08:04		HP85B found Parameters Okay & Ready for Exposure Start.
08:14	Hewlett Packard 9816	Exposure Timing started. [Time=T(0)]
08:15		TFE Chronic - Main Distribution Valve - Valve Opened
08:15		[LR] TFE Chronic - 1250 ppm Chamber Rats/Mice - Valve Opened
08:15		[LR] TFE - 1250 ppm -R/M -ON Exposure-Enable Environ Data Collection
08:15		[LR] TFE Chronic - 625 ppm Chamber Rats/Mice - Valve Opened
08:15		[LR] TFE - 625 ppm -R/M -ON Exposure-Enable Environ Data Collection
08:15		[LR] TFE Chronic - 312 ppm Chamber Rats/Mice - Valve Opened
08:15		[LR] TFE - 312 ppm -R/M -ON Exposure-Enable Environ Data Collection
08:15		[LR] TFE Chronic - 625 ppm Chamber Rats - Valve Opened
08:15		[LR] TFE - 625 ppm -R -ON Exposure-Enable Environ Data Collection
08:15		[LR] TFE Chronic - 312 ppm Chamber Rats - Valve Opened
08:15		[LR] TFE - 312 ppm -R -ON Exposure-Enable Environ Data Collection
08:15		[LR] TFE Chronic - 156 ppm Chamber Rats - Valve Opened
08:15		[LR] TFE - 156 ppm -R -ON Exposure-Enable Environ Data Collection
08:15		[LR] TFE Chronic - Standard Gas Valve - Valve Opened
08:27		[LR] TFE - 1250 ppm -R/M -T90 Time Expired-Including Conc Data
08:27		[LR] TFE - 625 ppm -R/M -T90 Time Expired-Including Conc Data
08:27		[LR] TFE - 312 ppm -R/M -T90 Time Expired-Including Conc Data
08:27		[LR] TFE - 625 ppm -R -T90 Time Expired-Including Conc Data
08:28		[LR] TFE - 312 ppm -R -T90 Time Expired-Including Conc Data
08:28		[LR] TFE - 156 ppm -R -T90 Time Expired-Including Conc Data
08:17	Hewlett Packard 85B	TFE - 1250 ppm -R/M-Conc Data Excluded-Data Time<T90 & Data<Target
08:19		TFE - 625 ppm -R/M-Conc Data Excluded-Data Time<T90 & Data<Target
08:21		TFE - 312 ppm -R/M-Conc Data Excluded-Data Time<T90 & Data<Target
10:25	Gary R. Ell	Service status updated on GC concentration from data collected
10:25		11-02-88 gas bag samples.No correction needed,as per Mr.
10:25		Rossignol.
10:26		Concentration Monitor-Service/Status
10:26		[1, 1]TFE - 1250 ppm -R/M Srv Date was: 27 Oct 1988 is: 3 Nov 1988
10:26		[1, 2]TFE - 625 ppm -R/M Srv Date was: 27 Oct 1988 is: 3 Nov 1988
10:26		[1, 3]TFE - 312 ppm -R/M Srv Date was: 27 Oct 1988 is: 3 Nov 1988
10:26		[1, 4]TFE - 0 ppm -R/M Srv Date was: 27 Oct 1988 is: 3 Nov 1988
10:26		[1, 5]TFE - (332) Room Srv Date was: 27 Oct 1988 is: 3 Nov 1988
10:26		[1, 6]TFE - 625 ppm -R Srv Date was: 27 Oct 1988 is: 3 Nov 1988
10:26		[1, 7]TFE - 312 ppm -R Srv Date was: 27 Oct 1988 is: 3 Nov 1988
10:26		[1, 8]TFE - 156 ppm -R Srv Date was: 27 Oct 1988 is: 3 Nov 1988
10:26		[1, 9]TFE - 0 ppm -R Srv Date was: 27 Oct 1988 is: 3 Nov 1988
10:26		[1,12]TFE - Standard Gas-H Srv Date was: 27 Oct 1988 is: 3 Nov 1988
14:27	Hewlett Packard 9816	[LR] TFE Chronic - Main Distribution Valve - Valve Closed
14:27		Exposure Terminated. Exposure timers stopped.
14:27		Generator valve already OFF.
14:27		[LR] TFE Chronic - 1250 ppm Chamber Rats/Mice - Valve Closed
14:27		[LR] TFE - 1250 ppm -R/M -OFF Exposure-Enable Environ Data Collection

Figure 12. Example of 24-Hour "Comment Summary" Printout from Data Acquisition and Control Computer. (Table shows a summary of all comments recorded on "Daily Log" printout.)

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Cage Maps

PROJECT: NTP-IRT
STUDY: TERATOLOGY
ROOM: 404

CHEMICAL: GALLIUM ARSENIDE
CHAMBER: CONTROL
DATE: 8/5/89 to 8/7/89
PJB

LEVEL 1

689	
643	
634	
623	
618	
606	
542	
531	

Grp A Rats

LEVEL 2

707	
659	
653	
624	730
502	704
484	688
466	489
437	468
431	455
391	~~439~~
384	~~404~~
369	~~396~~

DG 7 DIST SAC ON 3/2/87

Grp B Rats | Grp B Dist. Rats

LEVEL 3

654	727
638	620
560	592
536	588
530	582
523	547
465	533
447	509
372	482
364	417

Grp C Rats | Virgin Rats

LEVEL 4

302			
181		330	
177		319	
173	315	266	334
140	290	240	309
132	212	202	276
126	190	186	194
42	159	158	191
22	154	44	188
2	49	10	35

Virg Mice | Grp A Mice | Grp B Mice | Grp C Mice

LEVEL 5

1136	1177
1134	1170
1129	1168
1126	1158
1121	1153
1115	1152
1112	1145
1098	1143
1091	1142
1089	1140

Male Rats | Male Rats

LEVEL 6

1035	1076		
1027	1075		
1019	1074		
1018	1073		
1016	1058		
1015	1053		
1014	1052		
1008	1047		
1003	1044		

Male Mice | Male Mice

COMMENTS

PROJECT: NTP-IRT
STUDY: TERATOLOGY
ROOM: 404

CHEMICAL: GALLIUM ARSENIDE
CHAMBER: 1 mg/m3
DATE: 8/5/89 to 8/16/89
PJB

LEVEL 1

LEVEL 2

LEVEL 3

1043	1078		
1038	1069		
1029	1066		
1026	1064		
1024	1061		
1021	1059		
1006	1055		
1005	1048		
1004	1046		

Male Mice Male Mice

LEVEL 4

LEVEL 5

LEVEL 6

COMMENTS

PROJECT: NTP-IRT

STUDY: TERATOLOGY

ROOM: 404

CHEMICAL: GALLIUM ARSENIDE

CHAMBER: 10mg/m3

DATE: 8/5/89 to 8/7/89.
PdB

LEVEL 1

697	
694	
679	
672	
629	
614	
610	
602	
520	

Grp A Rats

LEVEL 2

706	
684	
677	
645	665
633	664
616	611
583	568
495	479
403	453
382	~~452~~
380	~~414~~
367	~~383~~

Dy 7 Disr Sac on 8/2/89.

Grp B Rats | Grp B Dist. Rats

LEVEL 3

716	709
656	632
649	625
635	607
597	486
562	477
480	429
458	401
443	379
438	366

Grp C Rats | Virgin Rats

LEVEL 4

335		308	
325		278	
234		255	
228	297	250	318
195	254	182	292
180	127	116	209
130	120	38	176
107	94	16	118
46	91	9	70
8	52	3	48

Virg Mice | Grp A Mice | Grp B Mice | Grp C Mice

LEVEL 5

1119	1176
1117	1174
1116	1171
1102	1169
1101	1164
1099	1161
1094	1144
1087	1137
1085	1135
1081	1130

Male Rats | Male Rats

LEVEL 6

1041			
1040	1071		
1037	1068		
1036	1067		
1033	1063		
1032	1060		
1028	1056		
1017	1051		
1010	1050		
1009	1049		

Male Mice | Male Mice

COMMENTS

PROJECT: NTP-IRT
STUDY: TERATOLOGY
ROOM: 404

CHEMICAL: GALLIUM ARSENIDE
CHAMBER: 37 mg/m3
DATE: 8/5/89 to 8/7/89
PUB

LEVEL 1

Grp A Rats
708
676
617
591
587
558
543
525

LEVEL 2

Grp B Rats	Grp B Dist. Rats
721	
661	
650	
644	690
608	681
599	680
594	669
593	636
575	613
571	~~[illegible]~~
381	~~[illegible]~~
370	~~[illegible]~~

Dg 7 Dist. Sac. on 5/2/89.

LEVEL 3

Grp C Rats	Virgin Rats
683	
652	728
639	703
626	658
598	657
561	546
496	529
492	517
435	493
396	444
377	378

LEVEL 4

Virg Mice	Grp A Mice	Grp B Mice	Grp C Mice
		324	
		310	
		289	350
		237	216
	270	223	204
	166	~~[illegible]~~	150
277	96	83	110
136	43	56	39

LEVEL 5

Male Rats	Male Rats
1125	1175
1123	1172
1109	1165
1106	1160
1105	1151
1096	1141
1088	1138
1084	1132
1080	1131
1079	1128

LEVEL 6

Male Mice	Male Mice		
1030			
1025	1077		
1022	1072		
1020	1065		
1013	1062		
1012	1057		
1011	1054		
1007	1042		
1002	1039		
1001	1034		

COMMENTS

PROJECT: NTP-IRT
STUDY: TERATOLOGY
ROOM: 404

CHEMICAL: GALLIUM ARSENIDE
CHAMBER: 75 mg/m3
DATE: 8/5/89 to 8/7/89
RJB

LEVEL 1

723	
717	
712	
711	
702	
698	
631	
574	

Grp A Rats

LEVEL 2

719	
714	
710	
667	675
663	622
642	595
603	567
499	449
457	403
442	404
421	396
411	393

D&T DIST. SAC. ON 8/2/89

Grp B Rats | Grp B Dist. Rats

LEVEL 3

687	715
678	695
584	685
535	637
518	627
494	540
474	527
446	504
407	472
389	405

Grp C Rats | Virgin Rats

LEVEL 4

		346	264
		280	238
	172	168	210
	167	164	205
268	34	106	114
104	27	88	17

Virg Mice | Grp A Mice | Grp B Mice | Grp C Mice

LEVEL 5

1120	1167
1111	1166
1107	1163
1104	1157
1100	1156
1097	1150
1092	1146
1090	1133
1086	1127
1082	1122

Male Rats | Male Rats

LEVEL 6

COMMENTS

APPENDIX G

QUALITY ASSURANCE

Quality Assurance Statement

Quality Assurance Statement

INHALATION DEVELOPMENTAL TOXICITY STUDY OF
GALLIUM ARSENIDE IN RATS AND MICE

Quality Assurance Statement

Listed below are the phases and/or procedures included in the study described in this report which were reviewed by the Quality Assurance Unit during the period, 6/01/89 - 8/31/89, or specifically for this study and the dates the reviews were performed and findings reported to management. (All findings were reported to the study director or his designee at the time of the review.)

Phase/Procedure Reviewed	Review Date	Date Findings Submitted in Writing to Study Director/Management
Animal Receipt	6/22/89*	6/28/89
Randomization	6/23/89	6/28/89
Identification	6/23/89	6/28/89
Data	7/06/89*	7/17/89
Health Screen	7/10/89*	7/31/89
Clinical Observations	7/11/89	7/31/89
Body Weights	7/11/89	7/31/89
Dosing	7/26/89*	7/26/89
Necropsy	8/08/89*	8/24/89
Data	2/[illegible] 9,13,15/90*	4/19/90
Final Report	4/16-20, 23-27/90 & 5/1-2,4/90 & 6/5-6/90,12/02/90*	12/03/90

* Reviewed specifically for this study.

Patricia S. Ruemmler — 12/3/90
Quality Assurance Auditor — Date

R A Gelman — 12/3/90
Quality Assurance Auditor — Date

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