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INTERNAL TECHNICAL REPORT

Title: VOLUME II, CALIBRATION OF THE LOFT MODULAR DTT AND
THE LOFT PRODUCTION DTT WITH A SMALL DRAG DISC

Organization: LOFT EXPERIMENTAL PROGRAMS DIVISION

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LOFT TECHNICAL REPORT
LOFT PROGRAM

MASTER

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EG&G INSTRUMENT CALIBRATIONS
AT KERNFORSCHUNGSZENTRUM KARLSRUHE

VOLUME II

CALIBRATION OF THE LOFT
MODULAR DTT AND THE LOFT
PRODUCTION DTT WITH A SMALL DRAG DISC

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Issue Date

February 1980

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KEK 2784

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4. Equations for the Primary Data and the Computer Variables
5. Calibration
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LOFT TEST SUPPORT BRANCH
EXPERIMENTAL DATA REPORT

KFK 2784

EG&G INSTRUMENT CALIBRATIONS AT KERNFORSCHUNGSZENTRUM KARLSRUHE

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Volume III - Calibration of Semiscale Instrumentation

Volume IV - Calibration of the KFK Impedance Probe and Gamma Densitometer

Volume V - Conclusion From Comparison of the Test Series and Other Relevant KFK Calibrations

1. INTRODUCTION

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Phase II of the LOFT Test program in Germany, consisted of two-phase flow calibrations in the three-inch pipe. The instruments intended for calibration were the LOFT Modular Drag Disk Turbine Transducer (MDTT) and a three-beam gamma densitometer. The DTT is of the modular design and is representative of the type to be used in the LOFT L2 (nuclear) series. The test section provides free field calibrations; that is, the DTT is smaller than the inside diameter of the test section. The gamma densitometer is a three beam unit representative of the configuration used in LOFT, but modified to fit on a smaller pipe.

The experiments are a continuation of the experiments reported in Volume I.

Data were obtained in a three-inch schedule 160 pipe in steady state flow. The major objectives of these tests were:

- (a) Obtain comparison performance data for the Modular vs the original plenum design DTT instrument.
- (b) Determine if the stiction in the LOFT modular drag disc was less than in the previous design.
- (c) Provide wider data base for the experiments reported in Volume I.

In addition to the instruments being tested, a three-beam gamma densitometer of the LOFT type was built to fit three or four inch schedule 160 pipe.

This report contains the experimental test description and the horizontal performance calibration data of the LOFT piping mass flow instrumentation. The testing was performed in the

Kernforschungszentrum Karlsruhe (KfK) facility at Karlsruhe, West Germany, in February 1978.

2. TEST PROGRAM SUMMARY, TEST LOOP DESCRIPTION, INSTRUMENTATION AND DATA ACQUISITION

Four test series were conducted; two with the MDTT at nominal pressures of 15 and 40 bars and two with a plenum DTT at nominal pressures of 15 and 40 bars. The reference mass flow rates were measured with orifices in single phase flow before mixing. In some experiments, radiotracer measurements were available which were able to measure the velocity of each phase, and in combination with the reference mass flow data, are capable of providing an estimate of the void fraction. A scanning (vertically traversing) reference gamma densitometer was used to provide void fraction distribution data.

2.1 Test Program Summary

The DTT (Drag Disk Turbine Transducer) testing at GfK in February, 1978 consisted of both single-phase calibration and two-phase tests. The tests included an experimental modular DTT design of the type used in the L2 series and a production plenum DTT design of the type used in the L1 series. The turbine in the experimental MDTT failed early in the testing. The failure appeared to be an open circuit in the ECT (eddy current transducer) resulting in no signal from the turbine. The open circuit in the ECT was pressure sensitive and apparently closed at lower pressures, and subsequent experiments involving the modular DTT transducer were conducted at 15 bars instead of 40 bars after the failure of the ECT. Lowering the test pressure to 15 bars resulted in obtaining eleven (11) additional two-phase test points with the modular DTT completely functional. The ECT then failed completely. Testing continued with just the drag disk unit of modular DTT functioning until a temporary shutdown of the test facility allowed replacement of the experimental MDTT with the fully functional production plenum DTT. The data on the

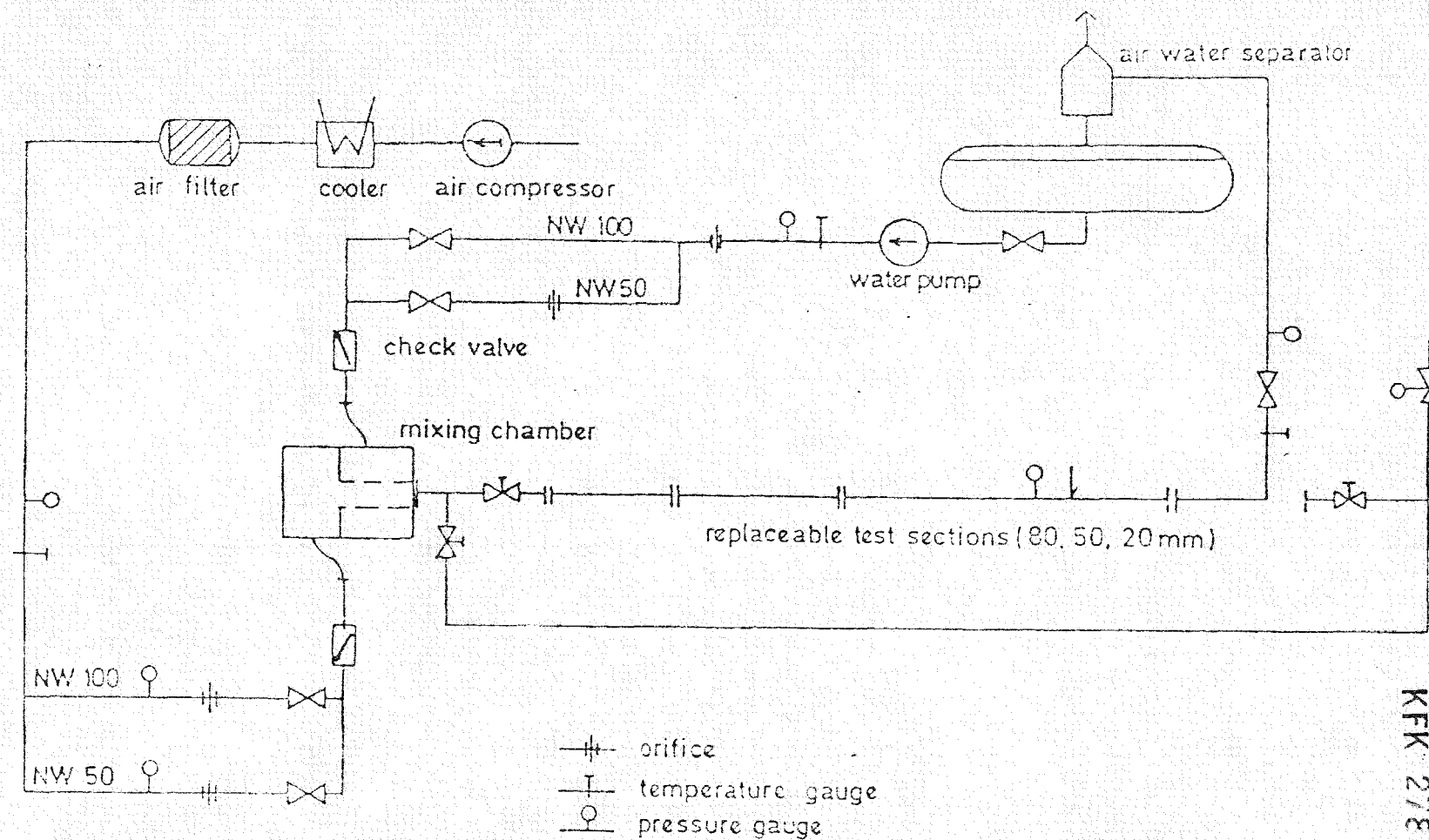
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drag disk of the MDTT is a completely different design than the production unit. These tests showed that there was considerably less stiction in the modular drag disk than the plenum unit. Due to the different ranges of the DTT's, the modular DTT has a drag disc of 1.52 cm (0.6 in.) in diameter and the production DTT has a drag disc of 0.76 cm (0.3 in.) in diameter.

The three-inch test section was installed and initial instrument calibration was accomplished on February 10, 1978. On February 22, 1978 the MDTT (Serial Number EXP-M-1) failed. The plenum DTT was installed on February 23, 1978, and testing continued with this unit until the final day of testing which was February 27, 1978.

2.2 Test Loop Description

A schematic of the facility is shown in Figure 2.1 and Figure 2.2. The facility is capable of either air-water (low pressure and temperature) operation or steam-water (high pressure, high temperature) operation. Different supply lines are used for the air-water system than for the steam-water system but the same mixer and test sections (described later) are used for both. The air-water system is supplied by a high volume water pump and four air compressors. After the air-water mixture goes through the test section, the individual phases are separated with the air being exhausted to the atmosphere and the liquid being recirculated. The steam-water mixture is supplied by two boilers. Two methods of operation are available. In the first, termed mixing runs, either boiler may be used to supply the steam. In the second method, either one or both boilers may be used to supply high pressure saturated liquid which is then flashed to a steam-water mixture. The mass flow rate through the test section can be controlled by the pump speed and air compressor control system in the air-water operation and by the boilers in the steam-water operation. Additional control is achieved in the steam-water operation by use of the boiler bypass.



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Fig. 2.1 Two phase air water loop

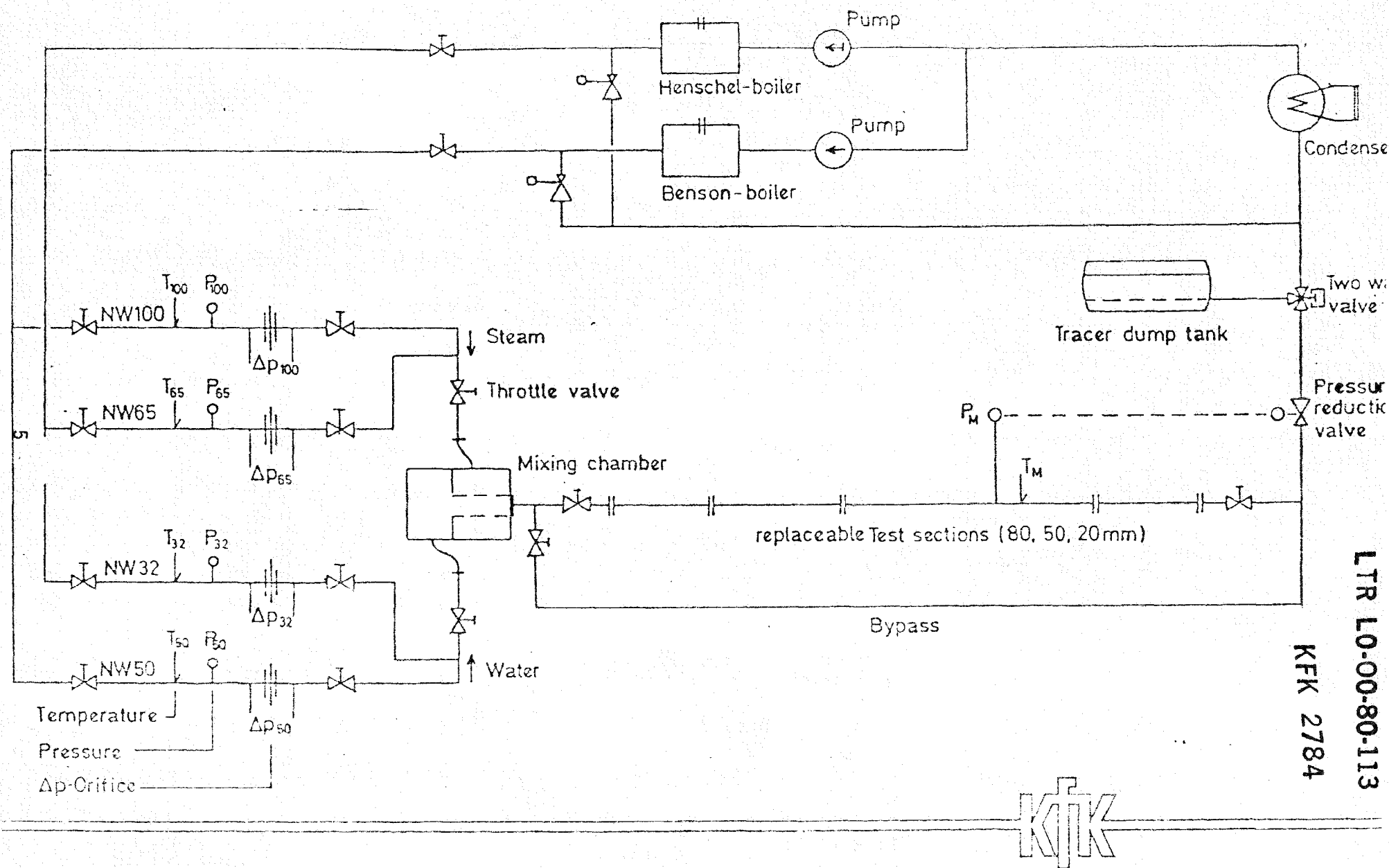


Fig. 2.2

Two phase steam water loop

For air-water flow testing, the published maximum loop capability is 30 kg/s water and 1.0 kg/s air at a pressure of 4 bar. Operating pressure can be increased to 10 bar at reduced maximum flow. For steam-water testing, two steam generators are used. The lower limits of flow are approximately 0.164 kg/s for water and 0.024 kg/s for steam at 25 bar pressure. At lower pressures and flows, accuracy of flow measurement decreases. With both steam generators producing steam, the upper flow limit is 3.75 kg/s. With both steam generators producing hot water, the upper limit is 5.5 kg/s. Throttling of the hot liquid alone can be used to produce qualities up to 20 percent. The flow rate capabilities versus quality are shown in Figure 2.3.

The two-phase loop consists of air-water and steam-water supply sections, mixing section and test sections. The reference flow measurement orifices are installed in the supply sections before the phase mixing.

2.2.1 Air-Water Supply Section. The schematic diagram for the air-water supply lines is shown in Figure 2.1 and Figure 2.4. Both the air input section and the water input section have three orifices with different measuring ranges. Both "A" orifices remain fixed, but the "B" and "C" orifices are interchanged. The dimensions of the pipe, orifices, the discharge coefficients of the orifices, and the thermal expansion coefficients of the orifices are given in Table 2-1.

2.2.2 Steam-Water Supply Section. The schematic diagram for the steam-water supply lines is shown in Figure 2.2 and Figure 2.5. There are two boilers; the Henschel Boiler and the Benson Boiler. For mixing runs, either of two combinations may be used: NW65 (steam line from Henschel) and NW50 (water line from Benson) or NW100 (steam line from Benson) and NW32 (water line from Henschel). For throttling runs, the water lines from both boilers, NW50 and NW32, are combined. The dimensions and coefficients of the pipes and orifices are given in Table 2-2.

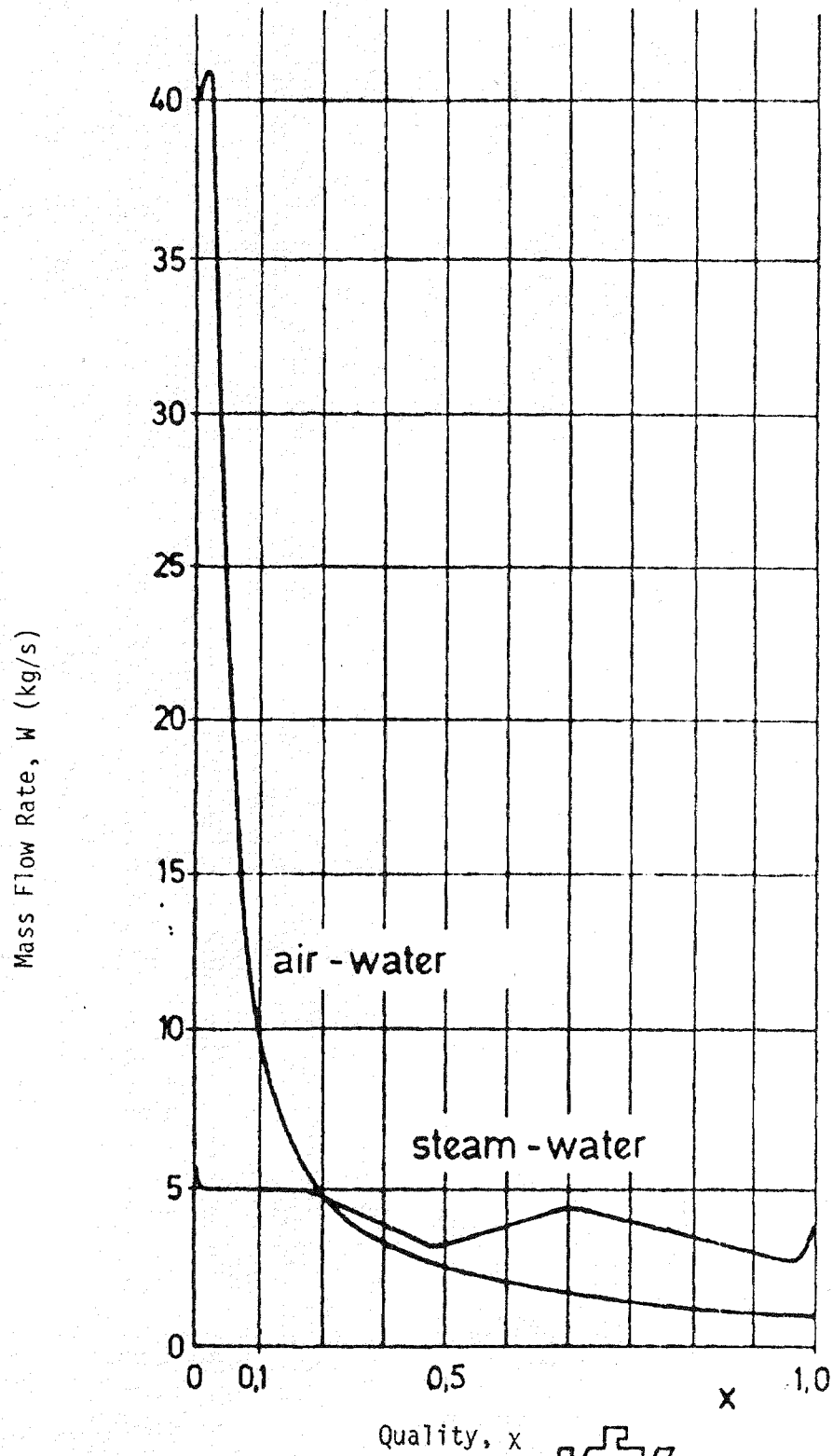
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Figure 2.3 Flow Rate Capabilities

AIR-WATER MIXING SECTION

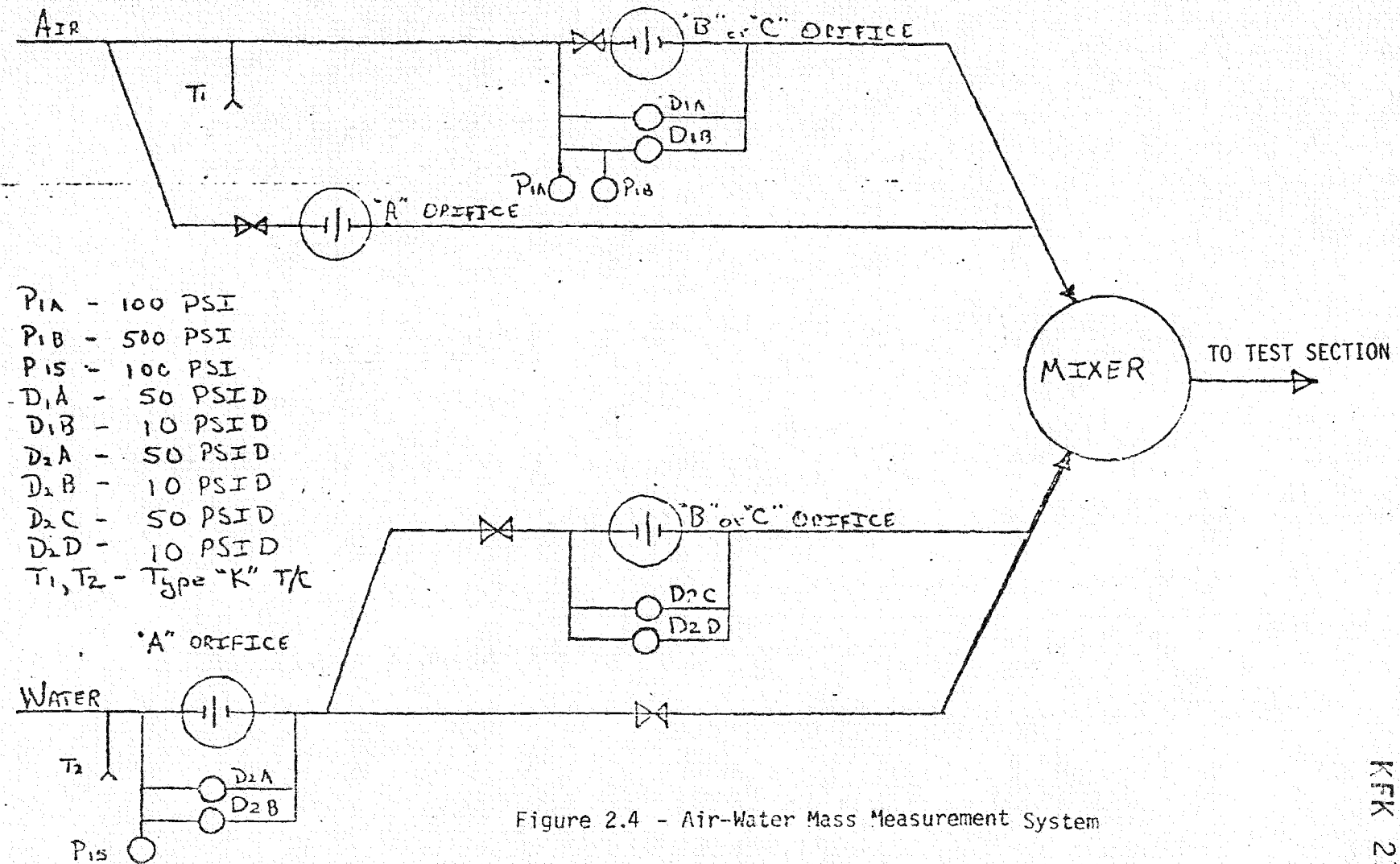


Figure 2.4 - Air-Water Mass Measurement System

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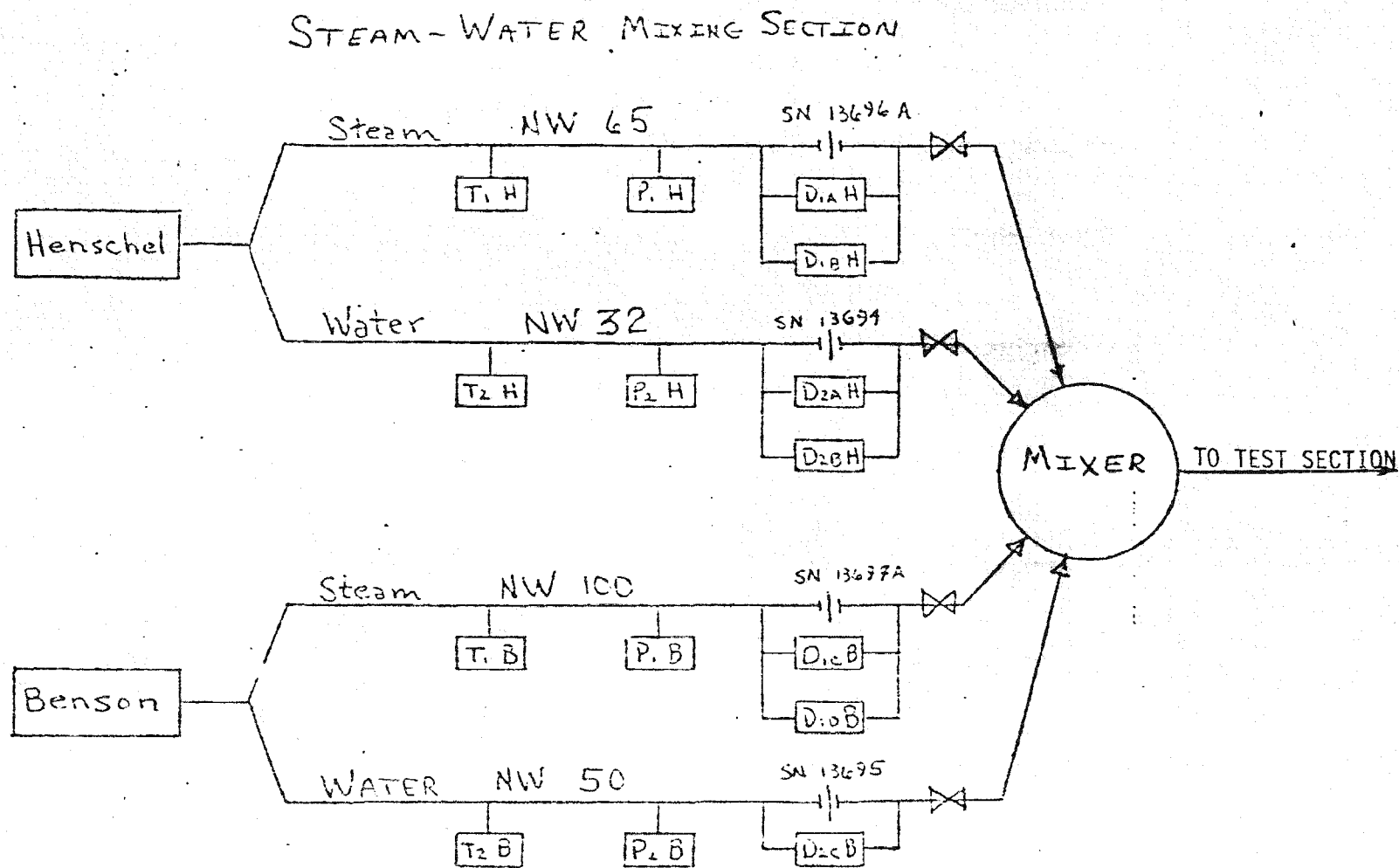


Figure 2.5- Steam-Water Mass Measurement System

TABLE 2-1

DIMENSIONS AND COEFFICIENTS OF PIPES AND ORIFICES FOR AIR-WATER SYSTEM

ORIFICE	D	d	C_d	ϵ
Air "A"	4.2165	1.4992	0.6132845	0.9785
Air "B"	2.0157	0.74567	0.6196883	0.9783
Air "C"	2.0157	0.3752	0.6113050	0.9789
Water "A"	4.2165	2.3445	0.6444408	1
Water "B"	2.0157	1.1618	0.6560336	1
Water "C"	2.0157	0.6000	0.6148216	1

D - Pipe diameter, inches

d - Orifice diameter, inches

C_d - Discharge coefficient, function of Reynolds number

ϵ - Thermal expansion correction factor

Mass Flow Rate

$$W = C_d \epsilon^2 A_o \sqrt{2\Delta P/\rho}$$

where

A_o = $d^2/4$, orifice area, m^2

ρ = density, kg/m^3

Δp = pressure drop across the orifice, N/m^2

TABLE 2-2

DIMENSIONS AND COEFFICIENTS OF PIPES AND ORIFICES FOR STEAM-WATER

ORIFICE - SN	D	d	C_d	ϵ_0	ϵ_1
NW 65 - SN 13696A	2.681	1.098	0.6127	1	0.0000116
NW 32 SN 13694	1.291	0.5906	0.6205	1	0.00000705
NW 100 - SN 13697A	3.917	1.7343	0.615	1	0.0000187
NW 50 - SN 13695	2.004	0.9043	0.6165	1	0.00000966

D - Pipe diameter, inches

d - Orifice diameter, inches

C_d - Discharge coefficient

ϵ - Thermal expansion coefficient, $\epsilon = \epsilon_0 + \epsilon_1 \cdot T$

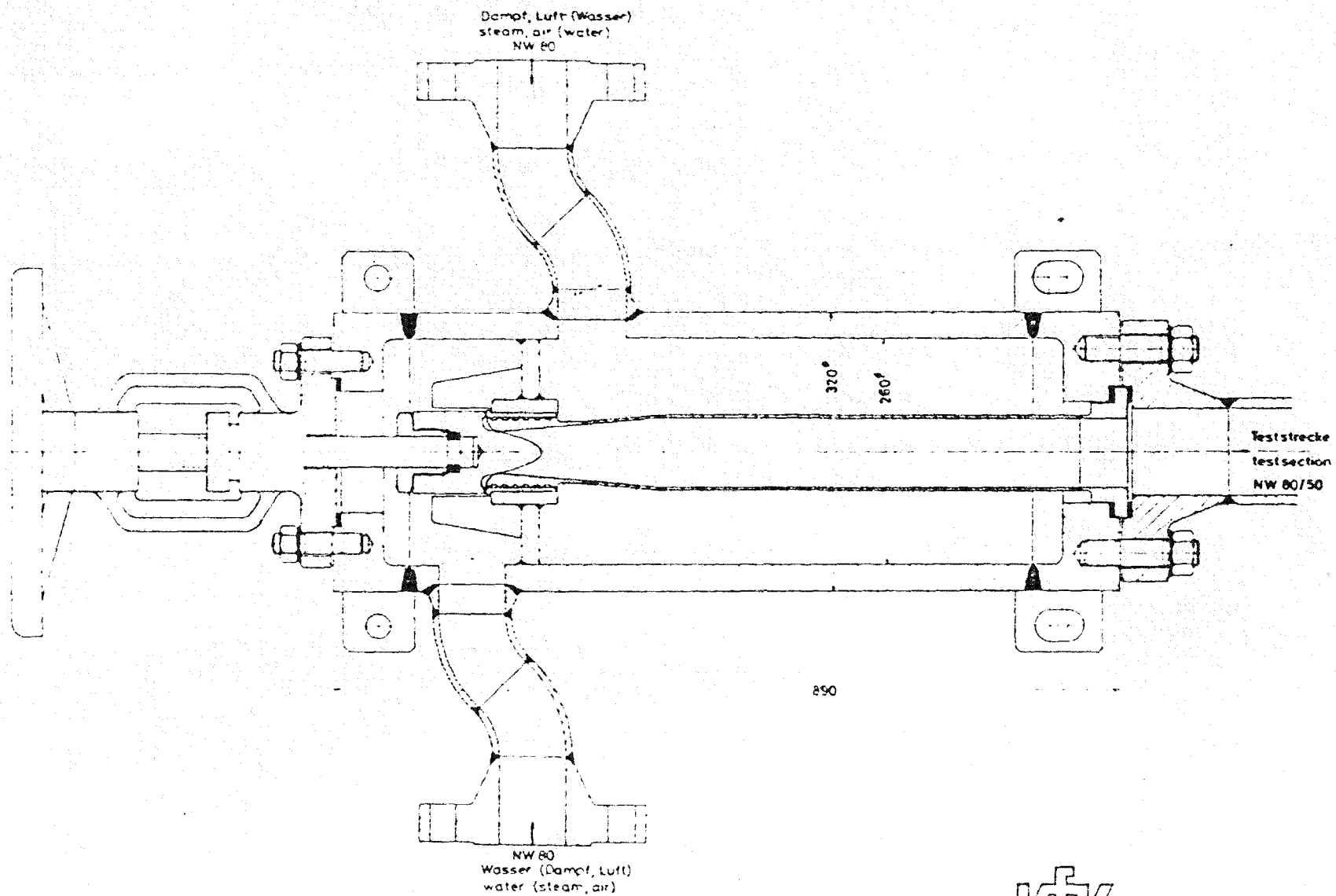
where T = temperature in² OF

2.2.3 Mixing Section. Figure 2.6 shows the mixing section.

Mixing of the phases is accomplished by means of a perforated tube. This tube has a wall thickness of 3 mm and contains about 600 drilled holes (diameter 2 mm) which are inclined slightly in the direction of the flow. For some tests, these holes were partly closed by a sleeve to make sure that even at low volumetric flows the pressure drop across the holes was big enough to ensure stable behavior of the mixing chamber. There are two methods of operating the mixing chambers. In the first method, steam flows through the center pipe and water is injected from the outer annulus into steam. In the second method, the mixing chamber is revolved by 180° so that water flows through the center pipe and steam is injected into the water from the outer annulus. The first method of operation may be used with other inserts for special purposes. For example, another insert is available to help promote a well developed annular mist flow in the test section. For the testing reported here, the second method of operation was used where steam is dispersed into water. This method of operation allows a closer approach to steam-water thermal equilibrium at the mixing chamber outlet.

There are two mixing chamber inserts available with outlet diameters of 50 and 80 mm. Between the mixing chamber outlet and the test section entrance, a connecting pipe (length 1.36 m; diameter 50 and 80 mm) which contained the junction to the bypass was positioned. In all the tests reported on in this volume, the 50-mm mixing chamber and 50-mm connecting pipe was used.

2.2.4 Test Section. The exit from the mixing section is 50 mm or 80 mm pipe. The three-inch test section is shown in Figure 2.7. The total length including adapters is 649 cm. The first and last sections adapt the 80-mm pipe to the three-inch section. The second and third pipe sections contain the radiotracer injectors and detectors and two fixed impedance probes. The fourth pipe section contains two gamma densitometers. The first is the LOFT three beam system. Because of support interference, the densitometer was mounted



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Figure 2.6 Mixing Section

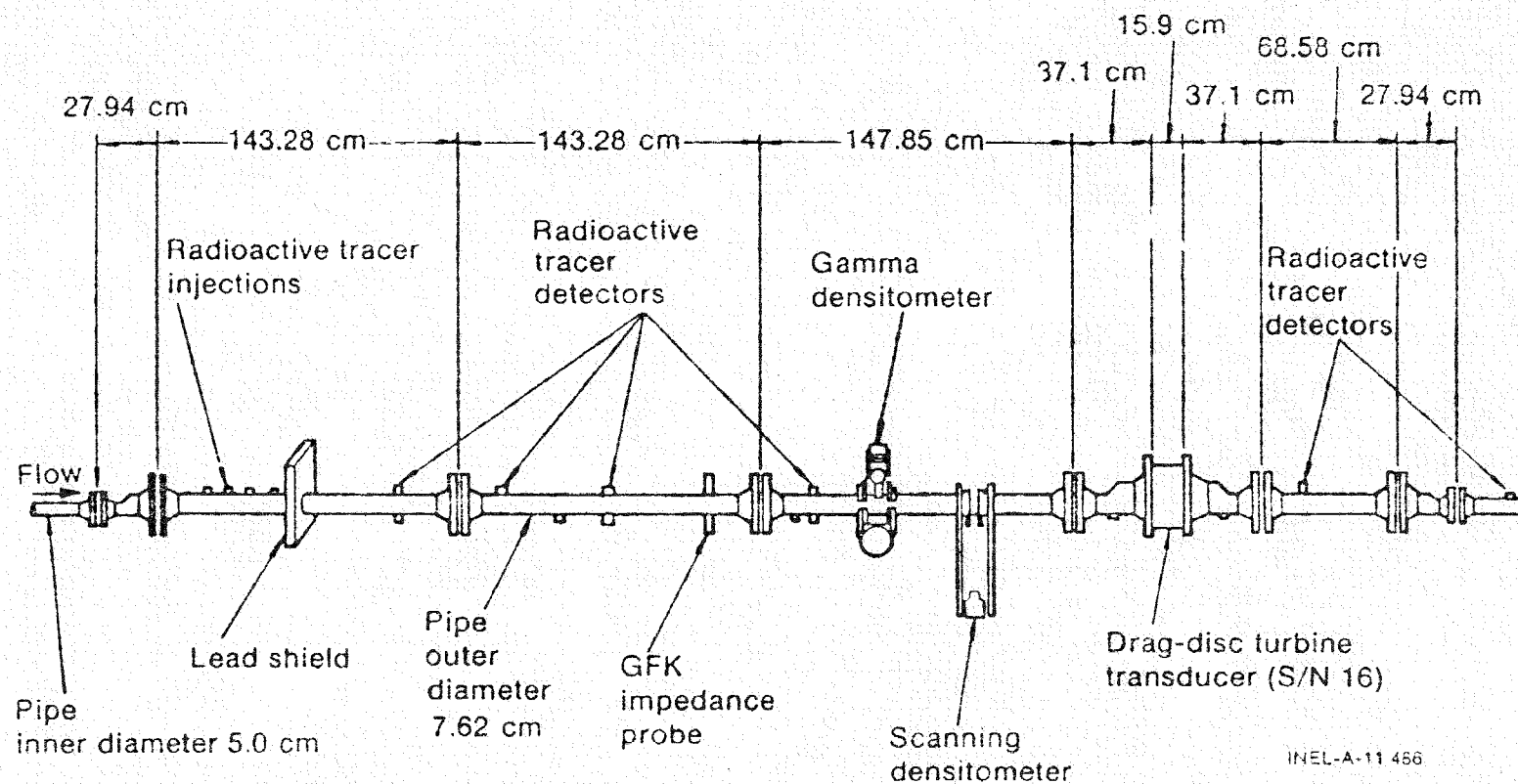


Figure 2.7 LOFT Three Inch Test Section

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upside down on the test section. The second is a scanning reference densitometer which was intended to supply the density distribution information on the three-inch pipe. The next three sections house the DTT and consist of the same three inch to five inch adapters used on the five-inch pipe and the DTT spool piece. A pipe insert has been added which keeps the internal diameter through these test sections the same as the rest of the three-inch pipe. A radiotracer detector is placed on the last section of three-inch pipe. Another is placed on the 80 mm pipe which should give further information on change in void fraction through a contraction.

2.3 Experimental Instruments

The advanced instruments which were used in these experiments were supplied by LOFT, Semiscale, Institut fur Reaktor Bauelemente (IRB), and Laboratorium fur Isotopentechnik (LIT). The advanced instruments supplied by LOFT, the drag disk turbine transducer (DTT) and the three-beam gamma densitometer (), were being calibrated in these tests. The advanced instruments supplied by the other organizations were used as supplementary measurements of the two-phase flow in the test section. The relative locations of the instruments were described in Section 2.2.4.

A schematic of the DTT installed in the test spool for the three-inch test section is shown in Figure 2.8. The drag disk is installed upstream of the turbine for all of the tests reported here. The same test spool was used for both test sections. A sleeve was inserted in each installation so that no pipe diameter changes occurred in the test spool. The drag disk (DD) force is measured by a linear variable differential transformer mechanically coupled to the drag disk. The turbine (T) rotation rate is measured by an induction coil pick up which senses passage of the blade. Detail drawings of the DTT are given in Appendix 7 of Volume I.

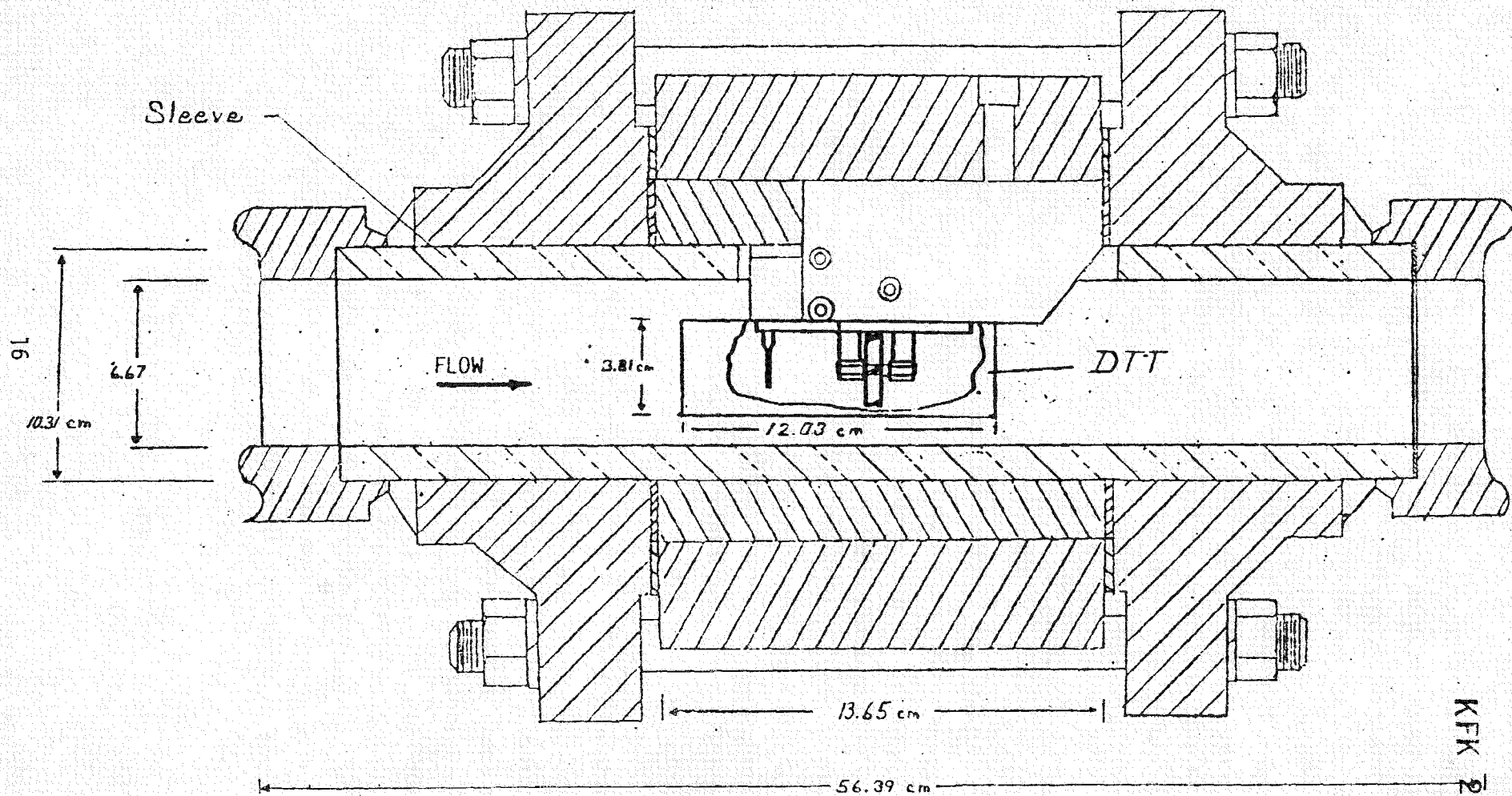


Figure 2.8 - DTT in Three Inch Pipe

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The LOFT three-beam gamma densitometer beam orientations for the three-inch test section are shown in Figure 2.9. The methods of averaging the beams to obtain an average density are also indicated in the figure. Both a beam length weighting method and a vertical beam span weighting method are used. Both methods usually produce similar averages. The beam orientation desired includes one beam through the bottom of the pipe, one beam through the center, and one beam near the annular flow. The beam size is approximately 1.27 cm in diameter. The source is located above the pipe in LOFT installations. It was necessary to mount the source below the three-inch test section because of interference between the detectors and the support structure. The details of the LOFT three-beam gamma densitometer are given in Appendix 7 of Volume I.

Impedance probes were used to measure the local void in the test section. The measurement principle is based on the different reflections of high frequency electric wave as a function of the terminating impedance at the open end of a coaxial line. The different terminating impedances are caused by the different electric losses to the two phases at the tip of the probe. Two fixed impedance probes were installed upstream of the gamma densitometer. The probe sensing tips were 10 mm from the top and the bottom of the pipe inside surface, respectively.

The traversing reference densitometer supplied by Semiscale was used on some of the experiments in the three-inch section to supply void fraction information. A diagram of this equipment is shown in Figure 2.10. This system uses a single source and a single detector. The source-detector combination rotates about a fixed point at the source location. This instrument is intended for use in steady state experiments. It scans the entire cross section of the pipe sequentially. In utilizing the scan information, the assumption is made that the value that the densitometer reads at a given location is constant. In actual operation, discrete readings are taken at 68 different radial positions to cover the pipe cross section. These

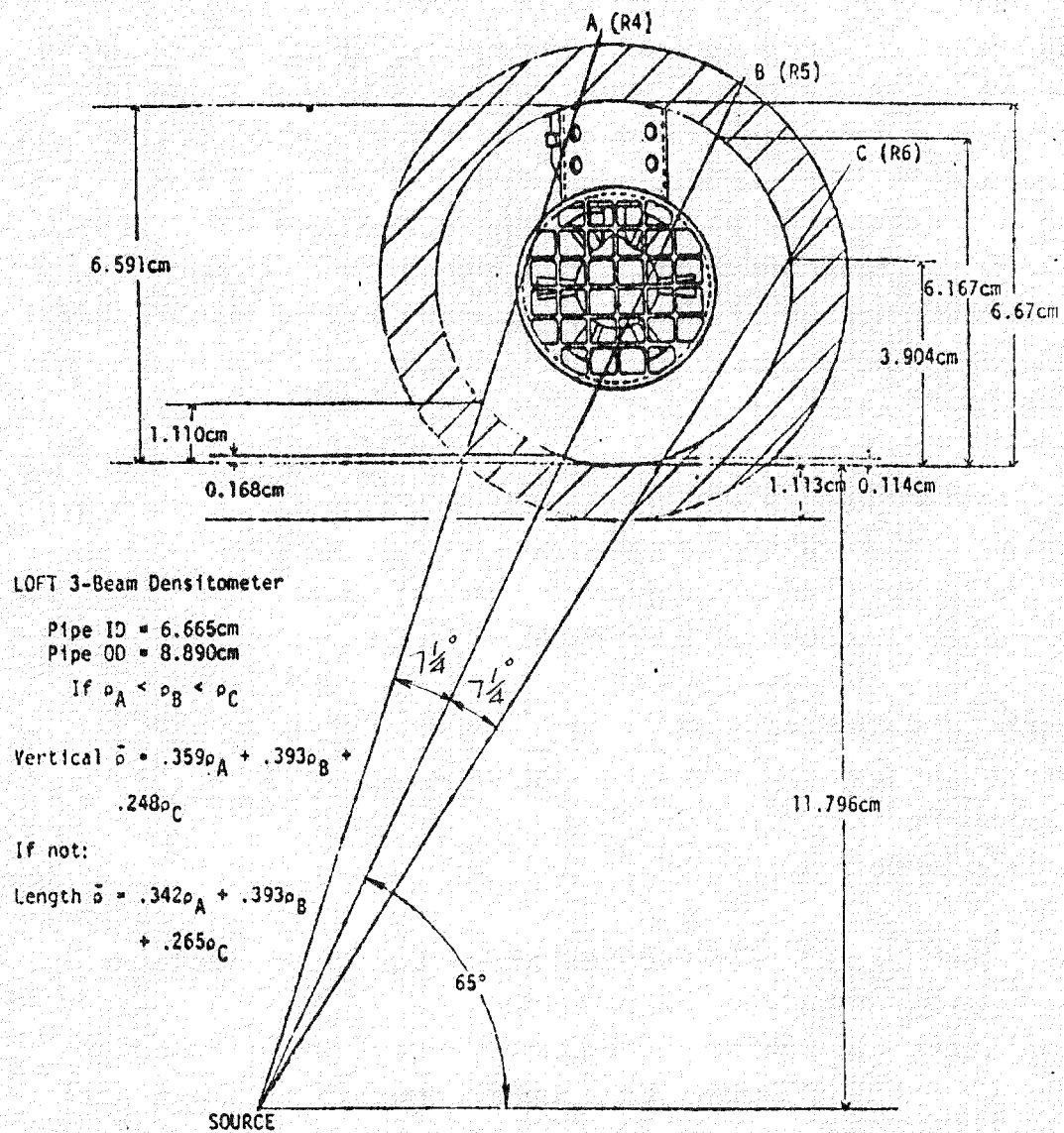
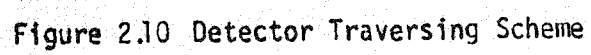


Figure 2.9 - Beam Orientation on the Three Inch Test Section



values are obtained with the use of a programmed positioner which stops at each of these positions and records a value integrated over three seconds. The resultant data can be used to plot a beam length averaged density versus vertical position in the pipe. Thus, it is seen that this instrument supplies the same type of information in the three-inch pipe that the impedance probe supplied in the five-inch pipe. The details of this equipment are described in Appendix 7 of Volume I.

The radioactive tracer injection technique which was used to measure the vapor and liquid velocities was supplied by the LIT. The injection ports were mounted as close as possible to the upstream end of the test section. Two ports were used to inject Argon-41 at the center and at the pipe wall, respectively, to measure the steam velocity. The other two ports were used to inject Manganese-56 in a similar manner for measurement of the liquid velocities. A minimum of three pairs of Scintillation detectors (NaJ) and photomultiplier tubes were utilized to determine the time between two detector ports. The phase velocities were determined using the time required for the radioactive tracers to travel between the detector axial locations, and the distance between the detector locations. The details of the technique is described in Appendix 7 of Volume I.

2.4 Data Acquisition

All reference values such as pressures and temperatures in the test section and upstream of the single phase orifices, and the pressure differences of the orifices are recorded analog by two H.u.B. (Hartmann und Brown) 12 point printers and digitally by the KfK PDP11/40 computer. The PDP11 also reports the calculated single phase flow rates and the total flow, and the temperature differences between the single phase and the saturation temperature. The quality (x), the void fraction (α), and the superficial steam and water velocities are calculated for the condition of the test section. The reference values for all the experiments are included in Appendix 2.

The LOFT data acquisition system consisted of Bay Laboratories signal conditioners and amplifiers, Ampex FR 1300 analog tape recorders, and Honeywell Strip Chart Recorders as well as all the peripheral specialized signal conditioning and monitoring and calibration equipment required for data acquisition. The outputs of the Bay Lab amplifiers were also input to a Hewlett-Packard 2100 computer with data printed out on a type 33 teletype printer. The strip chart recordings of the experimental instruments (except the radiotracer data) are included in Appendix 4. Time averaged values of the digitized analog data are included in Appendix 5.

3. SOURCES OF RECORDED DATA

This document contains hard copies of much of the recorded data. In addition, analog tapes are available for time analysis. Strip chart recordings are available for all of the LOFT recorded instruments. Calibration information is supplied in Section 5. A summary sheet is included in each experimental section which contains all the reference and experimental instrument measurements in engineering units. The remainder of this section summarizes all of the hard copy data contained in this report.

3.1 Operation Log and Set Up Sheets

This Appendix presents a log of each test as well as comments. Reference is made to each instrument-recording set-up for the given experiment. Setup sheets are included which relate the instrument identification to the apparatus diagrams in Section 2 and the channels which were recorded on the analog recorders and the strip charts. The amplifier settings are also included.

3.2 IRB Reference Values

The reference values of the flow rates are included in this section. The flow rates measured in each supply line are presented as well as the fluid conditions such as supply line pressure. The total mass flow is presented as well as the quality (uncorrected for heat loss), the void fraction (without slip), and the superficial velocities in the test section. The analog signals are reported by two 12 channel strip chart recorders.

3.3 Instrument Calibration Data

This appendix lists all the calibration data used and discussed in Chapter 5.

3.4 EG&G Strip Chart Recordings (Voltages)

Strip charts are presented which list the most important parameters as a function of time. The recording rate is 1 mm/sec. This allows the determination of which quantities fluctuate with time for a given experiment. The voltages presented may also be used to evaluate errors in the engineering values. Values of the LOFT three beam densitometer, turbine, and drag disk. Strip charts of the other recorded quantities are also available but not included in this report.

3.5 Time Averaged Digitized Analog Data (Voltages)

This Appendix contains the voltages obtained from the analog tapes by digitizing at a rate of 120 samples/second and averaging over a time period of 20 seconds.

4. EQUATIONS FOR THE PRIMARY DATA AND THE COMPUTED VARIABLES

The data in terms of computed variables are included in Sections 6 to 9 inclusive. The first sheet of each section presents all of the primary time average data in engineering units. That is, calibration equations have been applied to all the voltage readings to produce engineering units. All data manipulations are referred to as computed variables and are included in all the pages other than the first. This section describes the computation procedures used for both the primary engineering unit data and the computed variables data.

4.1 Primary Engineering Unit Data

The first portion of these data sheets consist of the pressure, temperaure, and reference flow rates. The second consists of advanced instrumentation data.

4.1.1 Reference Flow Rates. The reference mass flow rates for the air-water runs are calculated as described in Section 4.2.1 with no other corrections required. On the other hand, the steam-water mass flow rates of each phase must be corrected for phase change effects. Although the total mass flow is unchanged by these corrections, the total volumetric flow rate (or superficial velocity), the quality (x), and the void fraction (α) are affected by them. The method of correcting these mass flow rates includes the following:

- (1) The flow rate and thermodynamic conditions are given at the metering section for each stream. The liquid supply is subcooled and the vapor supply is superheated enough to insure that each stream is single phase through the measuring orifice. A check is made to ascertain that two-phase conditions are not encountered in the orifice.

- (2) Assuming that the heat loss through the piping walls and kinetic energy changes are negligible, each stream is throttled to the test section pressure (a constant enthalpy process)

$$W_1 h_1 (P_1, s_1) = W_1 h_1 (P_t, s_1^t)$$

$$W_2 h_2 (P_2, s_2) = W_2 h_2 (P_t, s_2^t)$$

Where W = mass flow rate
 h = enthalpy
 P = pressure
 s = entropy
 1 = conditions at metering section in stream 1
 2 = conditions at metering section instream 2
 t = test section conditions

- (3) The two streams are mixed assuming infinite heat transfer rate between the phases

$$W_t h'_t = W_1 h_1 + W_2 h_2$$

where h'_t is the mixture enthalpy neglecting the heat loss.

- (4) The heat loss between orifice and test section is subtracted from the mixture at constant pressure

$$W_t h_t = W_t h'_t - (0.1 T_t - 7^\circ\text{C}) \frac{860}{3600}$$

where T_t = saturation temperature in $^\circ\text{C}$ corresponding to P_t , h_t is in kcal/kg, and W_t is in kg/s.

The heat loss is often a small correction.

- (5) By definition, the mass flow rate of each phase in the test section is calculated from the flowing quality with the following equations except when x is outside the range of 0 to 1

$$W_g = W_t x$$

$$W_l = W_t (1-x)$$

A quality outside the range of 0 to 1 means that the flow was single phase, in which case the total mass flow, W_t would represent the single phase flow rate.

- (6) The flowing quality, x , can be calculated for the test section from the conservation of energy.

$$\begin{aligned} W_t h_t &= W_g h_g (P_t) + W_l h_l (P_t) \\ &= W_t x h_g (P_t) + W_t (1-x) h_l (P_t) \end{aligned}$$

where h_g and h_l refer to saturation properties of the gas and liquid phases at pressure P_t .

Solving for x yields.

$$x = \frac{h_t - h_l}{h_g - h_l}$$

The qualities reported in Appendix 2 are uncorrected for the heat loss of Step 4. The mass flow rates presented on the engineering unit data sheets in Chapter 7 through 11 have been corrected for this heat loss term.

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The superficial velocities, V_s , which represent the volumetric velocity divided by the full pipe area, are obtained by the equations

$$V_{sg} = \frac{W_g}{\rho_{g\text{sat}} \cdot A}$$

and

$$V_{sl} = \frac{W_l}{\rho_{l\text{sat}} \cdot A}$$

where $\rho_{g\text{sat}}$ and $\rho_{l\text{sat}}$ saturation densities of gas and liquid

respectively corresponding to the test section pressure, and A is the pipe cross-sectional area.

The vapor fraction referring to a two-phase mixture without slip is:

$$\alpha = \frac{x \cdot \rho_{l\text{sat}}}{(1-x) \cdot \rho_{g\text{sat}} + x \cdot \rho_{l\text{sat}}}$$

If both boilers are delivering saturated water and the steam is produced in the throttle valves before the mixing section by flashing, the above equations are used to calculate the superficial velocities, the steam quality and the vapor fraction in the test section.

Table 4.1 shows a typical printout from the IRB PDP11 if one boiler delivers water (Wasser) and the other steam (Dampf). Table 4.2 shows a printout where both boilers were delivering water and two-phase conditions are being obtained by throttling. The IRB output for all experiments is included in Appendix 2.

TABLE 4.1 - COMPUTER OUTPUT

STABILE VERSUCHSZUSTAENDE ERREICHT—①

RECHENWERTE

VERSNR = 7.0378
 ZEIT = 10:33:39

	P [BAR]	T [C]	DT [C]	H [KCAL/KG]	V [M/S]	MP [KG/S]
W	② 55.509	③ 239.131	-31.363	⑤ 246.595	⑮ 2.269	⑥ 3.236
D	⑦ 53.333	⑧ 293.344	⑨ 25.401	⑩ 690.554	⑯ 9.998	⑪ 0.730
M	⑫ 51.038	⑬ 262.468	④ 0.000	⑭ 327.130	0.000	⑫ 3.965
	X	ALFAH				
	X	X				
M	⑰ 0.129	⑱ 0.815				

TABLE 4.2 - Computer Output for
Throttling Runs

STABILE VERSUCHSZUSTAENDE ERREICHT-①

RECHENWERTE :MESS-STRECKE1:WASSER MESS-STRECKE2:WASSER

VERSNR = 17.0278

ZEIT = 11:16:21

	P [BAR]	T [C]	DT [C]	H [KCAL/KG]	V [M/S]	MP [KG/S]
V	② 40.423	③ 212.922	-38.003	④ 217.487	⑤ 1.239	⑥ 0.909
W	40.800	208.254	-43.223	212.485	3.400	2.929
M	⑫ 15.313	⑬ 197.089	0.000	⑭ 213.669	⑮ 0.000	⑯ 3.838
	X	ALFAH				
	0.01%	%				
	0.024	0.733				
	⑱	⑲				

The meaning of values in the PDP-11 output is described in the following:

- 1- "Stabile Versuchszustande Erreicht" means that water is slightly subcooled and steam is superheated so that single phase conditions are obtained in the orifice.

Conditions before either water orifice

- 2- Pressure, bar
- 3- Temperature, °C
- 4- Subcooling, °C
- 5- Enthalpy, kcal/kg
- 6- Mass flow (one or both orifices), kg/s

Conditions before either steam orifice

- 7- Pressure, bar
- 8- Temperature, °C
- 9- Superheating, °C
- 10- Enthalpy, kcal/kg
- 11- Mass flow, kg/s

Conditions in the test section at changeable location.

- 12- Pressure, bar

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- 13- Temperature, °C
- 14- Enthalpy of mixture, kcal/kg
- 15- Superficial velocity of water, m/s
- 16- Superficial velocity of steam, m/s
- 17- Total mass flow, kg/s
- 18- Steam quality
- 19- Void fraction

4.1.2 Advanced Instrumentation Data. The equation used to relate turbine velocity (V_T) values to voltages (T) for the Modular DTT is given by the equation (V_T)

$$V_T = 0.04548 \text{ [m/s]} + 1.407 \left[\frac{\text{m}}{\text{s} \cdot \text{volts}} \right] \cdot \text{voltsturbine}$$

Two different equations were used for the Plenum DTT:

15 bars

$$V_T = 0.0386 \text{ [m/s]} + 1.1874 \left[\frac{\text{m}}{\text{s} \cdot \text{volts}} \right] \cdot \text{voltsturbine}$$

and 40 bars

$$V_T = 0.0322 \text{ [m/s]} + 1.3468 \left[\frac{\text{m}}{\text{s} \cdot \text{volts}} \right] \cdot \text{voltsturbine}$$

The equation used to describe the modular drag disc output was:

$$(\rho V^2)_{DD} = -966.1 \text{ [kg/m}^2\text{]} + 2286.0 \left[\frac{\text{kg}}{\text{m} \cdot \text{s}^2 \cdot \text{volts}} \right] \cdot \text{volts}_{DD}$$

Two different equations were used for the plenum DTT:

15 bars

$$(\rho V^2)_{DD} = 1306.0 \left[\text{kg/ms}^2 \right] + 2593.0 \left[\frac{\text{kg}}{\text{m} \cdot \text{s}^2 \cdot \text{volts}} \right] \cdot \text{volts}_{DD}$$

and 40 bars

$$(\rho V^2)_{DD} = 1299.0 \left[\text{kg/ms}^2 \right] + 3001.0 \left[\frac{\text{kg}}{\text{m} \cdot \text{s}^2 \cdot \text{volts}} \right] \cdot \text{volts}_{DD}$$

The calibration of these instruments in single phase flow is described in Section 5.

The calibration equation for each gamma densitometer beam is related to the voltage by a logarithmic equation of the form:

$$\rho_i = X_i \ln (Y_i / \text{volts}_i \text{ beam})$$

and were calibrated daily.

The radiotracer technique is based upon measurement of the time that it takes a radiotracer to traverse a known distance. Thus, the velocity of a phase i , V_i , is estimated as

$$V_i = \frac{D_2 - D_1}{t_i}$$

where $D_2 - D_1$ = Distance between two detectors and t_i = time required for the radiotracer of phase "i" to traverse the distance between the two detectors.

The radiotracers may be injected at a rate of 10 injections per second so it is possible to determine the change in velocity with time.

4.2 Computed Variables

Most of the computed variables fall into four categories: the mass fluxes, the superficial velocities (volumetric flow rates), the vapor fraction, and the phase velocities. Other parameters are also calculated.

4.2.1 Mass Fluxes. The mass flux (G) can be calculated in three different ways by combining three instrument readings of density (ρ_y), turbine velocity (V_T), and drag disk momentum flux ($(\rho V^2)_{DD}$).

$$G_{Y-DD} = \frac{W_{Y-DD}}{A} = \sqrt{\rho_y \cdot (V^2)_{DD}}$$

$$G_{Y-T} = \frac{W_{Y-T}}{A} = \rho_y \cdot V_T$$

and

$$G_{T-DD} = \frac{W_{T-DD}}{A} = \frac{(\rho V^2)_{DD}}{V_T}$$

Each of these methods depends upon two of the measurements and not the third. Therefore, if one of the methods of calculating G is superior to the other two methods, then it can be supposed that the two measurements involved in that calculation of G are accurate and the inaccuracy involved in calculating the other two G 's is due to the third instrument.

The total mass flux is calculated by adding the mass flow rates of the two phases and dividing by the pipe area. The total steam-water mass flux can also be obtained from Appendix 2 by dividing the mass flow rate by the area.

The average density calculation is described in Section 4.2.3. The beam length averaged density is used in these calculations since it is negligibly different from the vertical beam span average.

The tabular values of the mass fluxes are given in Table 2 of each series. Comparisons of each of these mass fluxes to the reference mass flux is given in Figures 2 to 4 of each series. The numbers plotted on these figures and all others are the last two digits of the Test ID.

4.2.2 Superficial Velocity or Volumetric Flux. The total volumetric flux is calculated by adding the volumetric flow rates of each phase together and dividing by the pipe area. This is equivalent to adding the superficial velocities of both phases.

Two velocities are measured by the LOFT advanced instruments. The first is measured directly by the turbine (V_T). This is the only measurement which can be compared directly to a reference measurement. The second velocity is calculated from a combination of the drag disk and gamma densitometer as

$$V_{DD-\gamma} = \sqrt{\frac{(\rho V^2)_{DD}}{\rho_\gamma}}$$

The tabular values of these velocities are with reference values in Table 3 for each series. Figures 5 and 6 compare these velocities to the reference volumetric flux.

4.2.3 Pipe Averaged Density and Void Fraction Calculations. The average density is calculated by weighted average of the densities calculated for each beam. The procedure recommended in the L1 series consists of selecting between two different averages. If the density of the upper beam is less than the middle beam and if the middle beam is also less than the lower beam, then stratified flow is assumed. The average to be used in this instance is based upon weighting the

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vertical component of the beam length passing through the pipe (vertical beam span averaging). The average for homogeneous flow regimes is recommended as a weighting of the length of each beam (beam length averaging). Both of the beam averages are included in Section 2.3 for each test section. Both of these averages are included in Table 4 of each series for all data points. Since these averages are very close, the beam length averaged density is used in all the following calculations of computed variables. The densities measured by gamma densitometer vs reference densities are shown in Figure 10.

The vapor fraction in the test section may be calculated from the densities measured by the gamma densitometer:

$$\alpha_Y = \frac{\rho_Y - \rho_l}{\rho_g - \rho_l}$$

where ρ_g and ρ_l are the saturated densities of the gas and liquid respectively.

The thermodynamic vapor fraction (or vapor volumetric flow ratio, a flow quantity), α_T , can be calculated by the equation

$$\alpha_T = \frac{V_{sg}}{V_{sg} + V_{sl}} = \frac{\alpha_Y V_g}{\alpha_Y V_g + (1 - \alpha_Y) V_l} = \frac{\alpha_Y S}{\alpha_Y S + (1 - \alpha_Y)}$$

where V_g and V_l are the phase velocity of the gas and liquid phase. The ratio of α_Y and α_T is a measure of the slip between phases. As the slip ratio increases, the thermodynamic vapor fraction decreases.

The vapor fraction can also be calculated from the radiotracer velocities measured for each phase and the superficial velocity of each phase. The vapor fraction calculated from the vapor phase is

$$\alpha_{Rg} = 1 - \frac{V_{sg}}{V_g}$$

The vapor fraction calculated from the liquid phase is

$$\alpha_{Rl} = 1 - \frac{V_{sl}}{V_l}$$

Agreement between α_{Rg} and α_{Rl} provides a measure of the accuracy of the radiotracer velocities and the reference flow rates. If these two values agree, then the agreement between α_R and α_γ provides a measure of the accuracy of the gamma densitometer vapor fraction.

Table 4 of each test series presents the comparison between these vapor fractions. A comparison of the radiotracer vapor fractions are presented in Figure 7.

4.2.4 Phase Velocity Comparison. The velocity of each phase can be calculated from the superficial velocities and the gamma densitometer vapor fractions as

$$V_{\gamma g} = \frac{V_{sg}}{\alpha_\gamma}$$

and

$$V_{\gamma l} = \frac{V_{sl}}{1 - \alpha_\gamma}$$

A comparison of these velocities to the radiotracer velocities are presented in Table 5.

The slip ratio is calculated for sets of velocities by the equations

$$S_Y = \frac{V_{Yg}}{V_{Yl}}$$

and

$$S_R = \frac{V_g}{V_l}$$

4.2.5 Comparisons to Single Instruments. Three quantities were calculated to attempt to evaluate individual instruments. The turbine is evaluated directly by comparing it to the total superficial velocity shown in Figure 5.

A reference density can be calculated from reference values assuming equal phase velocities by the equation

$$\rho_H = \frac{G_{ref}}{V_{sl} + V_{sg}}$$

The value of the length averaged gamma densitometer density is plotted versus ρ_H in Figure 10.

Two different reference momentum fluxes can be calculated. The first is obtained using only reference measurements assuming that the velocities are equal.

$$(\rho V^2)_H = (G)_{ref} (V_{sl} + V_{sg})$$

The other momentum flux which can be calculated depends upon the densitometer measured void fraction (α_Y) by using the definition

$$\rho V_Y^2 = (\alpha_Y \rho_g V_g) V_g + ((1-\alpha_Y) \rho_l V_l) V_l$$

or

$$\rho V_Y^2 = G_g \cdot \frac{V_{sg}}{\alpha_Y} + G_l \cdot \frac{V_{sl}}{(1-\alpha_Y)}$$

The drag disk value is evaluated by comparing the drag disc

outputs with $(\rho V^2)_H$ in Figure 11 and with ρV_Y^2 in Figure 12.

These values are presented in Table 8.

4.2.6 The Dependence of Measurement Error On Void Fraction. The interested measurement quantities, mass flux and velocity, is thought to be dependent on void fraction. The deviations of the measured mass flux and velocity plotted versus void fraction are shown in Figure 8 and 9 respectively for the turbine and gamma densitometer.

4.3 Flow Regime Determination

The flow regime can be estimated from three different techniques; (1) a standard flow regime map, (2) the LOFT three-beam gamma densitometer, and (3) the IRB impedance probe on the five-inch test section reported in Volume I and the Semiscale reference gamma densitometer on the three-inch test section.

4.3.1 Standard Flow Regime Map. The flow regime map used was taken from Govier and Axix (1972:523) and converted to metric units. This flow regime map requires knowledge of the superficial velocities of each phase. The coordinates of each data point are plotted on a flow regime map in Figure 1a in each series and the flow regime indicated is listed in Table 6.

4.3.2 LOFT Three-Beam Gamma Densitometer Technique. The gamma densitometer used in these tests provided three beams, from which three chordal average densities were calculated. The beam

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orientations were as shown in Figure 2.9. The densitometer is designed to clamp onto a pipe of variable diameter and was used on all tests. The gamma source was of sufficient strength to preclude the need for any special piping sections to lower the shielding effects of the pipe. The chordal average densities obtained by the three-beam gamma densitometer can be processed by computer to obtain flow regime and pipe cross-sectional average density information.

The frequency response of the densitometer is limited only by count rate statistics. The densitometer, as used in these tests, was capable of a minimum frequency response of 100 Hz. The accuracy of the densitometer is also a function of count rate statistics, as well as other factors. A 2σ accuracy of $\pm 20 \text{ kg/m}^3$ should be applied to the data obtained with the three-beam densitometer in these tests.

4.3.3 Impedance Probe Technique. The impedance probe data on the five-inch tests were obtained with the traversing impedance probe which was able to give experimental data as a function of vertical position over the whole pipe. At a given location in the pipe, the probe gives the vapor volume fraction versus time. This allows the determination of an average vapor volume fraction at that location as well as an indication of the size of the bubbles, droplets, or slugs passing by a point. Combining the data at all vertical positions yields a good idea of the flow structure details as well as the average void fraction over the pipe. The details of how this method is employed are described in Section 13 of Volume I. The flow regime map obtained from this technique as well as the definition of the flow regimes are also described in Section 13 of Volume I. Figure 1b in each data section presents the data on the revised flow regime map.

4.3.4 Reference Gamma Densitometer Technique. The reference densitometer is characterized by a fixed source, a small exposed detector area, and a traversing mechanism to move the detector in an arc about the source point (as shown in Figure 2.10) to obtain data at many chordal positions over the flow field. The detector was a

liquid-nitrogen-cooled silicon semiconductor having excellent photon energy resolution. The use of a low-energy characteristic X-ray emitting source (Cadmium-109) was facilitated by incorporation of a beryllium ring between a pair of flanges in the pipe spool piece. The 22 keV X-rays provided near optimum densitometer sensitivity in the 66.7-mm diameter flow area of the piping spool piece. The beryllium pressure containing ring permits use of such low-energy photons because the ring attenuates than even less than does the contained liquid. This arrangement also provides improved capability to distinguish between flow regimes by means of the shape of traverse count rate and chordal average density data.

Chordal average density values are calculated from detected X-ray count rates using

$$\rho_c(\theta) = \rho_f - (\rho_f - \rho_g) \frac{\ln \frac{I(\theta)}{I_f(\theta)}}{\ln \frac{I_g(\theta)}{I_f(\theta)}}$$

where

- $\rho_c(\theta)$ = chordal average two-phase mixture density at detector position θ
- $I_f(\theta)$ = X-ray count rate at θ for all-liquid condition in pipe
- $I_g(\theta)$ = X-ray count rate at θ for all-vapor pipe condition
- $I(\theta)$ = X-ray count rate at θ for two-phase condition
- ρ_f = density of liquid giving I_f count rates
- ρ_g = density of vapor giving I_g count rates.

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4.3.5 Water Level Estimation. The assumption can be made that there is a collapsed water level to estimate whether single phase or two phase is flowing through the DTT. The location of the water level can be determined by knowing the vapor fraction α_Y . The value of α_Y can be determined as

$$\alpha_Y = \frac{\text{vapor area}}{\text{total area}}$$

or

$$\alpha_Y = 1 - \frac{1}{2\pi} (\theta - \sin \theta)$$

The height of the water level with respect to the bottom of the pipe is

$$H = \frac{D}{2} [1 - \cos (\frac{\theta}{2})]$$

The percent of the DTT height covered by the liquid can be calculated by

$$P_3 = \frac{H - 1.427 \text{ cm}}{3.81 \text{ cm}} \times 100 \text{ percent}$$

These values are included in Table 6.

5. CALIBRATION

The data in this report were taken with Modular DTT S/N Exp-M-1 and Plenum DTT S/N 087703. The specified limits of these instruments are T from 0.46 to 9.15 m/s and DD from 373 to 5215 kg/ms². The calibration of the instruments in these devices in single phase flow are reported in this section. There were four series of calibrations performed. These are:

- (1) An all cold water calibration of the MDTT.
- (2) An all cold water calibration of the plenum DTT at 15 bars.
- (3) An all hot water calibration at 40 bars using the MDTT.
- (4) An all hot water calibration at 40 bars using the plenum DTT.

These data are tabulated in Appendix 3. Turbine data are plotted in Figure 5.1 and the drag disk data are plotted in Figure 5.2. Continuous lines were drawn visually through the test points for each of the series. The coefficients which were used to obtain turbine velocities and drag disk momentum fluxes from voltage outputs were given in Section 4.1.2. These equations are shown as dashed lines in Figure 5.1 and 5.2, respectively.

Reference instrumentation at GfK supplied by INEL consisted of pressure, temperature, differential pressure and density instruments. Table 5.1 summarizes the uncertainties associated with this instrumentation. Calibrations for the pressure, temperature, and differential pressure instrumentation were conducted at INEL facilities prior to shipment to the GfK test facility. The gamma densitometers were calibrated prior to each day of testing. The calibration of the densitometer consisted of setting the gain and zero offset of each beam such that a predetermined calibration equation was correct. The reference conditions for the densitometer calibration were obtained by

filling the test section with steam and then water. Shim calibrations were not used. No calibrations of other reference instrumentation were conducted at the KfK facility.

Radiotracer velocities were also obtained.

Fluid Velocity (m/s)

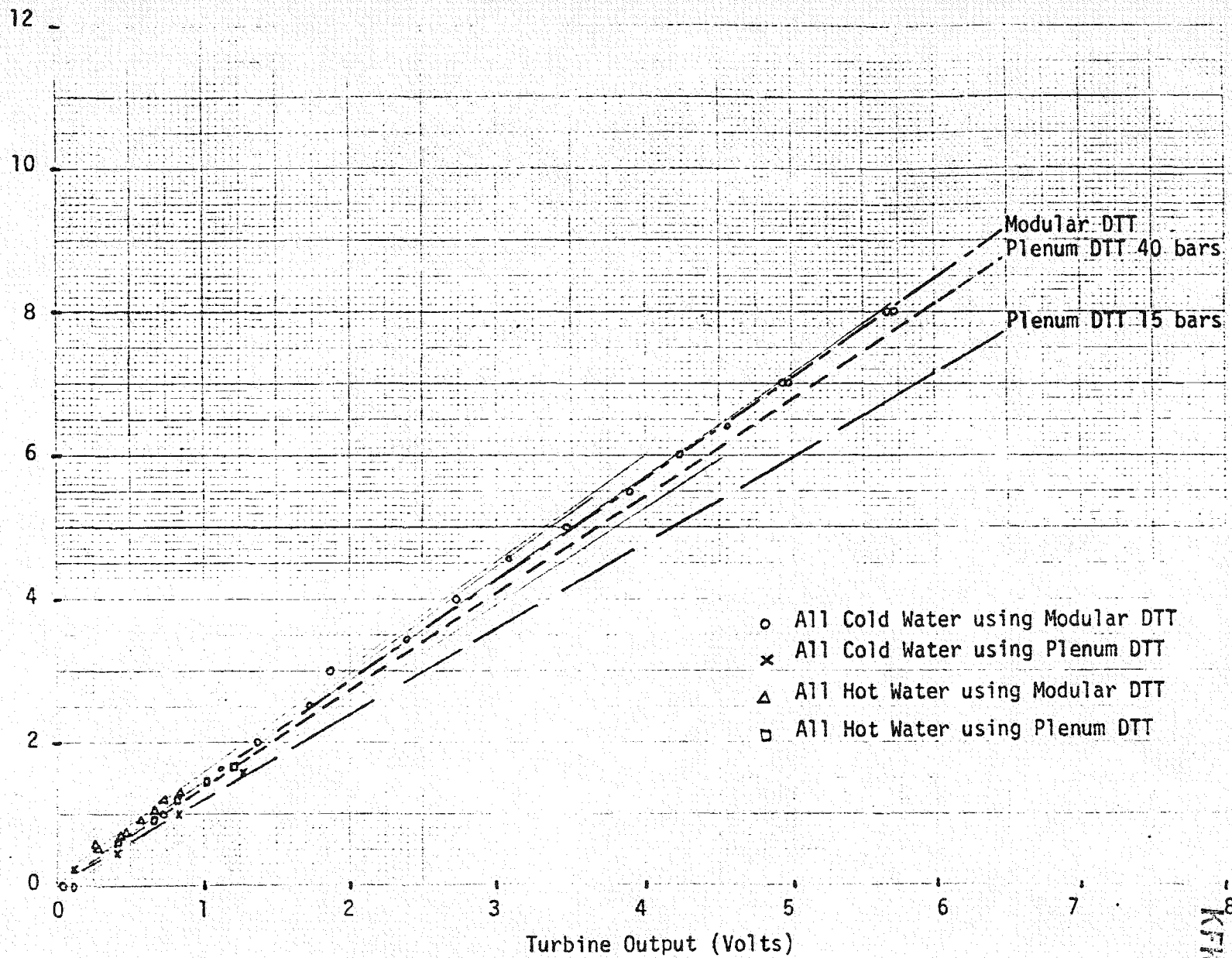


Figure 5.1 Turbine Calibration in Single Phase

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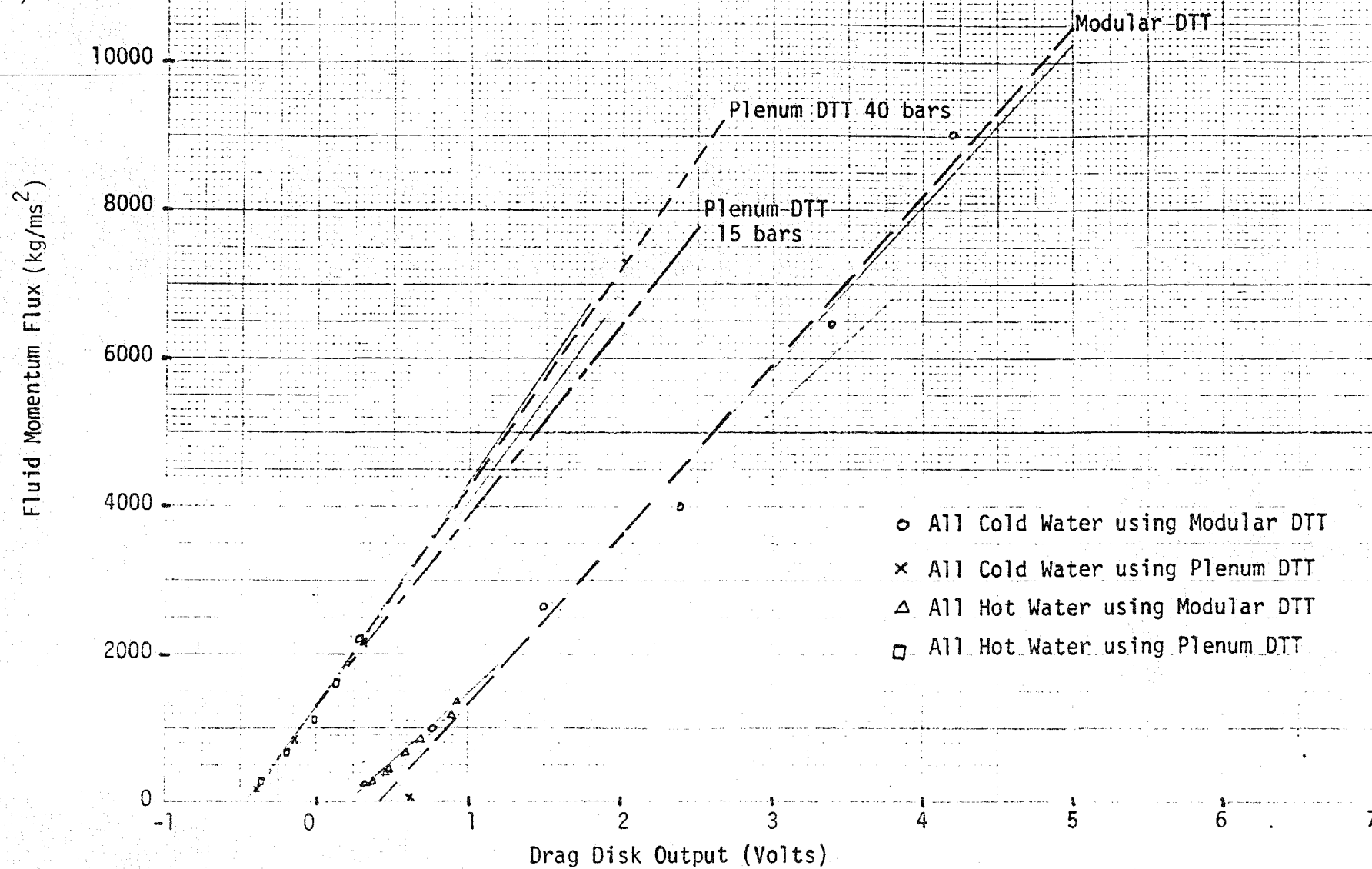


Figure 5.2 Drag Disk Calibration in Single Phase

TABLE 5.1

INEL REFERENCE INSTRUMENTATION AT GFK TWO-PHASE TESTS

<u>Instrument Type</u>	<u>Serial Number</u>	<u>Uncertainty*</u>
<u>Pressure</u>		
CEC 1000	2611	
	2613	
CEC 2500	2353	<u>+0.1% RD RSS 11 psi</u>
	2734	
<u>Differential Pressure</u>		
BLH 50"	42694	<u>+0.16% RD RSS 0.07 psid</u>
BLH 20"	39192	
<u>Temperature</u>		
Type K TC	none	<u>+4.2% RD</u>
<u>Density</u>		
3-beam	none	<u>+23.9 kg/m³ single beam</u>
Gamma Densitometer		<u>+78.0 kg/m³ pipe average density</u>
Scanning Gamma Densitometer	none	about 1%

*Uncertainty is 2 σ limits from LOFT Experimental Measurements
 Uncertainty analysis TREE-NUREG-1089

RD - Reading
 RSS - Root Sum Square

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6. THREE INCH STEAM-WATER 15 BAR
MODULAR DTT

Table 6.1

PRIMARY ENGINEERING UNIT DATA

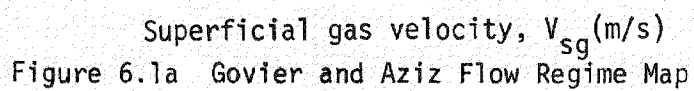
FLUID: STEAM - WATER
 PIPE SIZE= 3 INCH SCHEDULE 160
 NOMINAL PRESSURE= 15 BARS

INSIDE DIAMETER= 0.06665 M
 TURB. DIA.= 0.0381 M
 PIPE AREA= 0.0034889 M²

PHASE II - MODULAR DTT

RUN ID	PRESS. (BARS)	TEMP. (DEG C)	FLOW RATES				TURB. VEL (M/S)	DRAG DISK (KG/ M* ² S)	GAMMA DENSITOMETER			SCAN DENS (KG/ M ³)	RADIOTRACER VELOCITIES	
			STEAM SUP-VEL (M/S)	MASS (KG/S)	WATER SUP-VEL (M/S)	MASS (KG/S)			A BEAM UPPER (KG/ M ³)	B BEAM MIDDLE (KG/ M ³)	C BEAM LOWER (KG/ M ³)		STEAM (M/S)	WATER (M/S)
TSN													(AT GAMMA DENS)	
7059	15.2	195.6	2.02	0.053	1.563	4.729	1.62	2659	667	725	842	456		
7060	15.6	198.5	1.91	0.052	1.562	4.717	2.19	3619	436	532	728	414		
7061	16.0	199.3	0.96	0.029	1.568	4.725	1.61	2675	617	717	800			
7062	15.8	197.8	2.69	0.075	1.539	4.642	3.31	3233	262	381	515	413		
7063	16.1	201.4	2.83	0.080	1.534	4.624	2.70	3365	310	429	562	357		
7064	14.1	194.2	8.85	0.220	1.221	3.711	7.66	3472	-	257	357	204		
7065	15.0	200.4	1.91	0.053	1.089	3.284	1.45	1630	403	534	702	447		
7066	16.1	198.9	0.28	0.007	1.113	3.355	1.09	1205	736	822	808			
7067	15.2	196.0	1.35	0.038	1.121	3.388	1.59	1753	391	524	685	490		
7068	15.4	196.0	2.62	0.071	1.111	3.329	2.44	1832	218	363	517	314		
7069	12.8	188.4	8.74	0.200	0.924	2.823	7.83	2205	73	228	304	186		
7076	17.7	203.2	0.63	0.020	1.342	4.018		1648	672	724	823	661		
7077	17.7	203.2	1.37	0.044	1.330	3.982		2177	470	531	715	497		
7078	16.9	201.4	2.24	0.068	1.317	3.956		2168	256	422	587	347		
7079	15.9	201.1	3.56	0.101	1.256	3.786		2264	235	315	476	269		
7080	16.4	198.9	9.81	0.284	1.275	3.833		3840	162	242	401			
7081	14.3	194.9	15.75	0.392	1.213	3.689		7501	120	189	247			
7082	15.5	198.2	3.77	0.104	0.747	2.254		620	170	276	446			
7083	16.3	201.4	0.43	0.012	0.782	2.354		250	745	886	837			
7088	15.9	198.5	1.49	0.041	0.637	1.921		309	382	457	684	311		
7089	17.6	204.7	0.26	0.008	0.666	1.994		259	673	738	853	707		
7090	17.2	202.9	1.04	0.032	0.663	1.990		499	431	502	724	430		
7091	17.5	205.7	3.94	0.120	0.718	2.152		786	213	287	442	277		
7092	14.7	194.9	9.24	0.241	0.750	2.274		1939	137	217	343	187		
7093	19.2	206.8	0.92	0.031	0.680	0.834		-	279	359	527	501		
7094	17.3	201.8	1.22	0.038	0.840	2.519		915	412	485	674	486		
7095	17.4	204.0	0.29	0.010	0.837	2.566		567	800	851	823	800		

dash indicates error in data
 blank indicates no data



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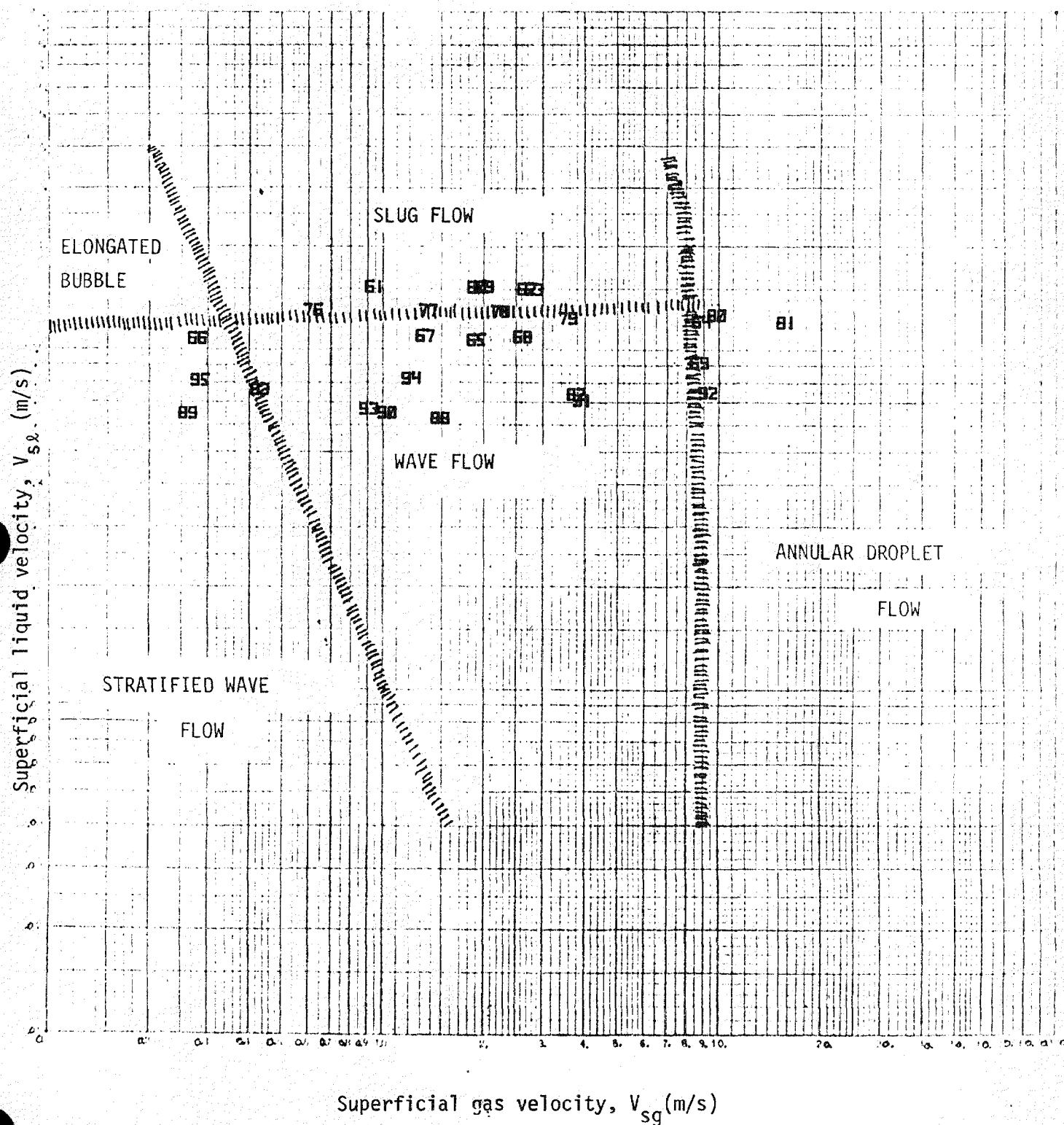


Figure 6.1b Impedance Probe Flow Regime Map

Table 6.2

MASS FLOW RATE COMPARISONS

PHASE II - MODULAR DTT
3 INCH 15 BAR

RUN ID	GDOT REF	GDOT G-T	GDOT G-DD	GDOT T-DD
TSN	(KG/M ² *S)	(KG/M ² *S)	(KG/M ² *S)	(KG/M ² *S)
7059	1370.633	1194.953	1399.186	1638.324
7060	1366.906	1204.843	1412.002	1654.778
7061	1362.607	1134.078	1373.110	1662.523
7062	1352.002	1243.296	1102.486	977.623
7063	1348.276	1144.714	1193.763	1244.913
7064	1126.716			453.501
7065	956.462	773.053	932.533	1124.914
7066	963.628	856.438	974.825	1109.576
7067	981.971	827.468	955.442	1103.210
7068	974.519	864.009	805.428	750.820
7069	866.462	1526.941	655.577	281.465
7076	1157.385		1098.425	
7077	1153.945		1102.988	
7078	1153.372		980.257	
7079	1114.105		864.363	
7080	1181.748		992.529	
7081	1169.710		1163.277	
7082	675.858		420.181	
7083	678.151		445.412	
7088	562.355		389.644	
7089	573.820		439.752	
7090	579.552		517.674	
7091	651.208		487.500	
7092	720.858		657.418	
7093	247.929			
7094	732.896		683.087	
7095	721.144		684.417	

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Table 6.3
TOTAL VELOCITY COMPARISONS

PHASE II - MODULAR DTT 3 INCH 15 BAR			
RUN ID TSN	VSL+VSG (M/S)	TURB. VEL (M/S)	VEL. DD-G (M/S)
7059	3.585	1.623	1.900
7060	3.474	2.187	2.563
7061	2.523	1.609	1.948
7062	4.232	3.307	2.932
7063	4.367	2.703	2.819
7064	10.072	7.656	
7065	2.997	1.449	1.748
7066	1.395	1.086	1.236
7067	2.468	1.589	1.835
7068	3.726	2.440	2.275
7069	9.664	7.834	3.363
7076	1.967		1.500
7077	2.702		1.974
7078	3.561		2.212
7079	4.815		2.619
7080	11.088		3.869
7081	16.963		6.448
7082	4.513		1.477
7083	1.216		0.562
7088	2.128		0.793
7089	0.930		0.590
7090	1.702		0.965
7091	4.655		1.612
7092	9.991		2.949
7093	1.597		
7094	2.063		1.340
7095	1.124		0.828

Table 6.4

VOID FRACTION COMPARISONS

PHASE II - MODULAR DTT
3 INCH 15 BAR

RUN ID TSN	DENSITIES (KG/M ³)			VAPOR FRACTIONS			
	VERT AVG GAMMA	LEN AVG GAMMA	SCAN DENS	ALPHA GAMMA (LEN)	ALPHA SCAN DENS	ALPHA THERMO	RADIOTRACER VAPOR FRACTION STEAM WATER
7059	733.30	736.26	455.61	0.16	0.48	0.56	
7060	545.95	550.91	413.53	0.37	0.53	0.55	
7061	701.72	704.83		0.19		0.38	
7062	371.66	375.96	412.71	0.57	0.53	0.64	
7063	419.22	423.50	357.11	0.52	0.59	0.65	
7064			204.18		0.77	0.88	
7065	528.42	533.51	447.17	0.39	0.49	0.64	
7066	787.41	788.62		0.09		0.20	
7067	515.75	520.75	498.15	0.41	0.43	0.55	
7068	349.02	354.10	313.55	0.60	0.65	0.70	
7069	190.99	194.91	185.91	0.78	0.79	0.90	
7076	729.55	732.12	661.31	0.15	0.23	0.32	
7077	554.66	558.83	446.62	0.35	0.49	0.51	
7078	439.30	443.22	347.21	0.49	0.60	0.63	
7079	325.90	330.00	269.19	0.63	0.70	0.74	
7080	252.48	256.54		0.71		0.89	
7081	178.24	180.40		0.80		0.93	
7082	279.88	284.58		0.68		0.83	
7083	791.68	793.25		0.08		0.36	
7088	486.52	491.65	311.82	0.44	0.65	0.70	
7089	742.72	745.78	707.47	0.14	0.18	0.28	
7090	531.64	536.62	409.42	0.38	0.53	0.61	
7091	298.50	302.40	236.97	0.66	0.73	0.85	
7092	219.40	222.90	181.66	0.75	0.80	0.92	
7093	371.89	376.10	505.28	0.57	0.41	0.57	
7094	505.44	509.90	426.44	0.41	0.51	0.59	
7095	825.90	826.30	808.23	0.04	0.06	0.26	

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Table 6.5
PHASE VELOCITY COMPARISONS

PHASE II - MODULAR DTT 3 INCH 15 BAR						
RUN ID TSN	V GAS G DENS (M/S)	V GAS RADIO (M/S)	V LIQ. G DENS (M/S)	V LIQ. RADIO (M/S)	SLIP G DENS	SLIP RADIO
7059	12.986		1.851		7.015	
7060	5.177		2.477		2.090	
7061	5.058		1.933		2.617	
7062	4.707		3.597		1.309	
7063	5.488		3.171		1.731	
7064						
7065	4.879		1.788		2.728	
7066	3.101		1.224		2.533	
7067	3.322		1.885		1.762	
7068	4.372		2.765		1.581	
7069	11.142		4.286		2.599	
7076	4.142		1.580		2.621	
7077	3.872		2.060		1.880	
7078	4.564		2.591		1.761	
7079	5.690		3.353		1.697	
7080	13.813		4.403		3.137	
7081	19.682		6.072		3.242	
7082	5.548		2.325		2.386	
7083	5.115		0.855		5.986	
7088	3.409		1.132		3.011	
7089	1.953		0.770		2.537	
7090	2.722		1.072		2.539	
7091	6.005		2.085		2.881	
7092	12.307		3.011		4.088	
7093	1.619		1.568		1.032	
7094	2.963		1.430		2.071	
7095	6.954		0.873		7.966	

Table 6.6
FLOW REGIME COMPARISONS

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RUN ID TSN	From Govier & Aziz Flow Regime Map	From Gamma Densitometer		Reference Densitometer	
		Flow Regime	Interface Location(%)*	Flow Regime	Interface Location(%)*
7059	Slug Flow		100.42		
7060	Slug Flow		67.75		
7061	Slug Flow		94.92		
7062	Slug Flow		41.21		
7063	Slug Flow		47.32		
7064	Slug Flow		---		
7065	Slug Flow		64.74		
7066	Elongated Bubble		113.01		
7067	Slug Flow		61.72		
7068	Slug Flow		36.44		
7069	Slug Flow		10.34		
7076	Slug Flow		101.84		
7077	Slug Flow		70.74		
7078	Slug Flow		51.26		
7079	Slug Flow		32.14		
7080	Slug Flow		20.37		
7081	Slug Flow		7.25		
7082	Slug Flow		24.93		
7083	Elongated Bubble		115.01		
7088	Slug Flow		57.81		
7089	Elongated Bubble		103.93		
7090	Slug Flow		66.46		
7091	Slug Flow		27.88		
7092	Slug Flow		15.08		
7093	Slug Flow		40.78		
7094	Slug Flow		61.72		
7095	Elongated Bubble		122.62		

*Pipe Empty: 0.0 cm liquid level is -37.47%
 Pipe Full: 6.665 cm liquid level is 137.47%
 Bottom of DTT Housing: 1.4275 cm liquid level is 0.0%
 Top of DTT Housing: 5.2375 cm liquid level is 100.0%

Mass Flux Calculated from Densitometer and Turbine Measurements

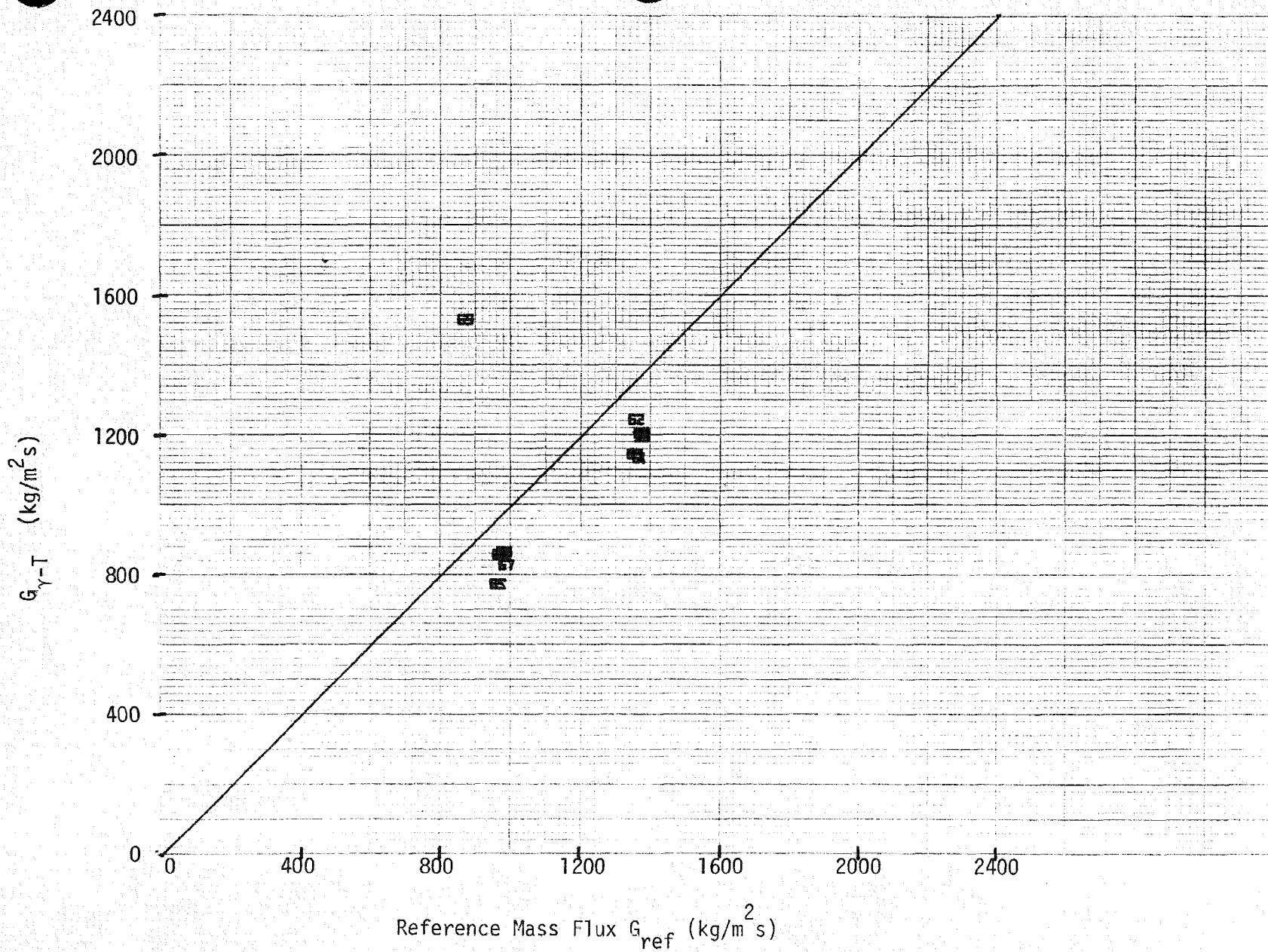


Figure 6.2 Mass Fluxes Calculated from Gamma Densitometer and Turbine Measurements at Different Reference Values

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Mass Flux Calculated from Densitometer and Drag Disc

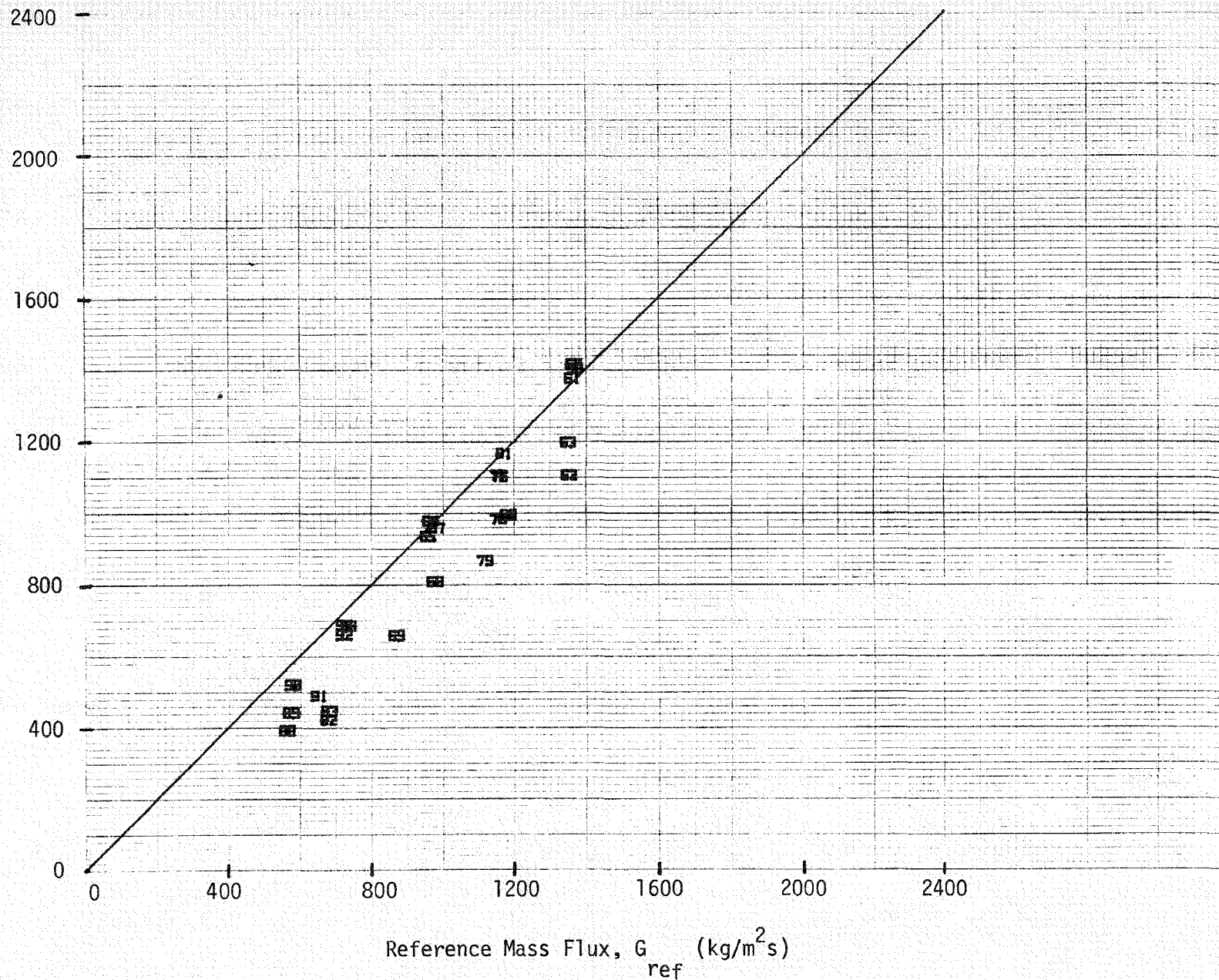
Measurements, G_{Y-DD} ($\text{kg/m}^2\text{s}$)

Figure 6.3 Mass Fluxes Calculated from Gamma Densitometer
Drag Disc Measurements at Different Reference Values

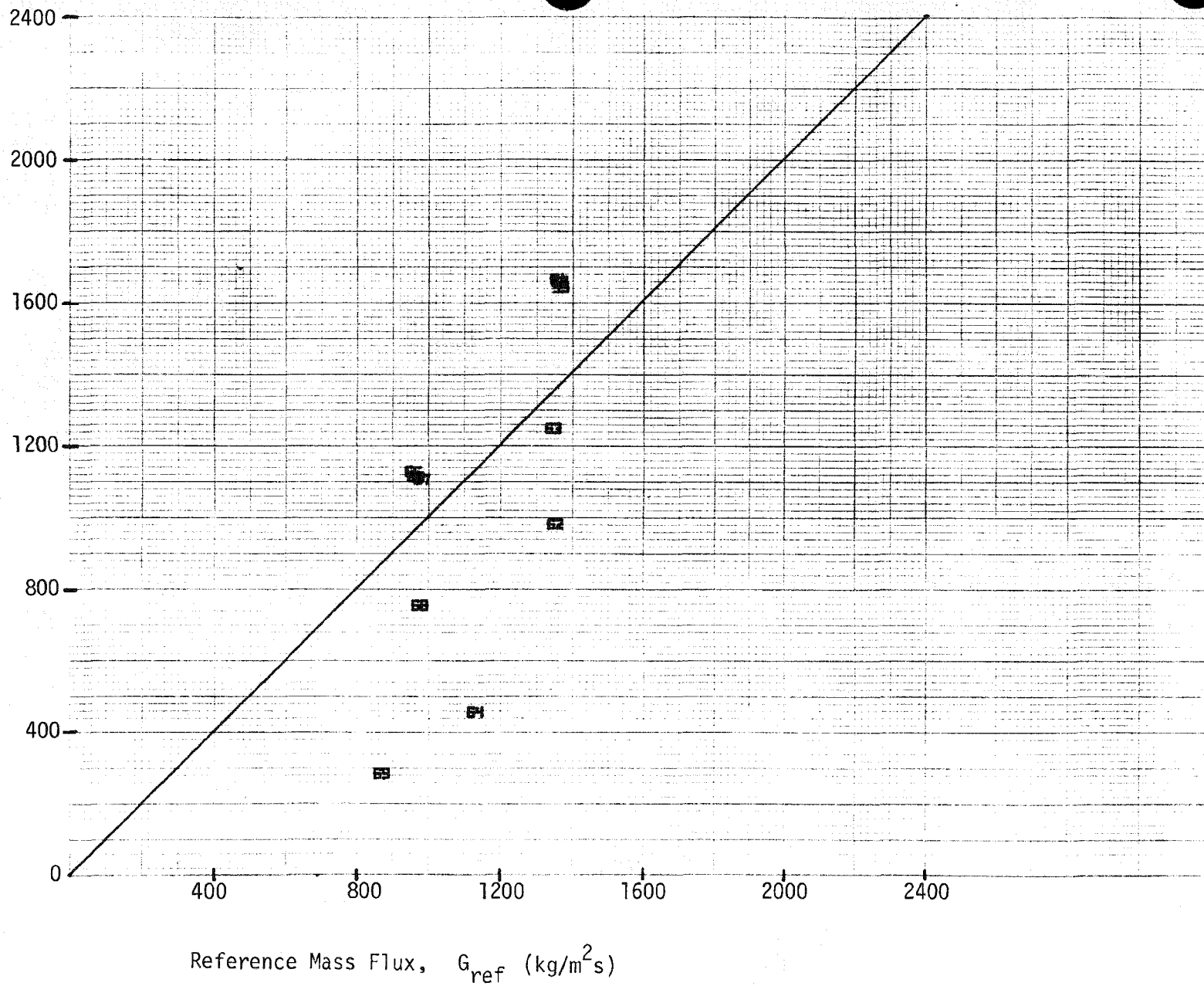
KFK 2734

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Mass Flux Calculated from Turbine and Drag Disc Measurements

G_{T-DD} ($\text{kg/m}^2\text{s}$)



Reference Mass Flux, G_{ref} ($\text{kg/m}^2\text{s}$)

Figure 6.4 Mass Fluxes Calculated from Turbine and Drag Disc Measurements at Different Reference Values

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Velocity Measured by Turbine, V_T (m/s)

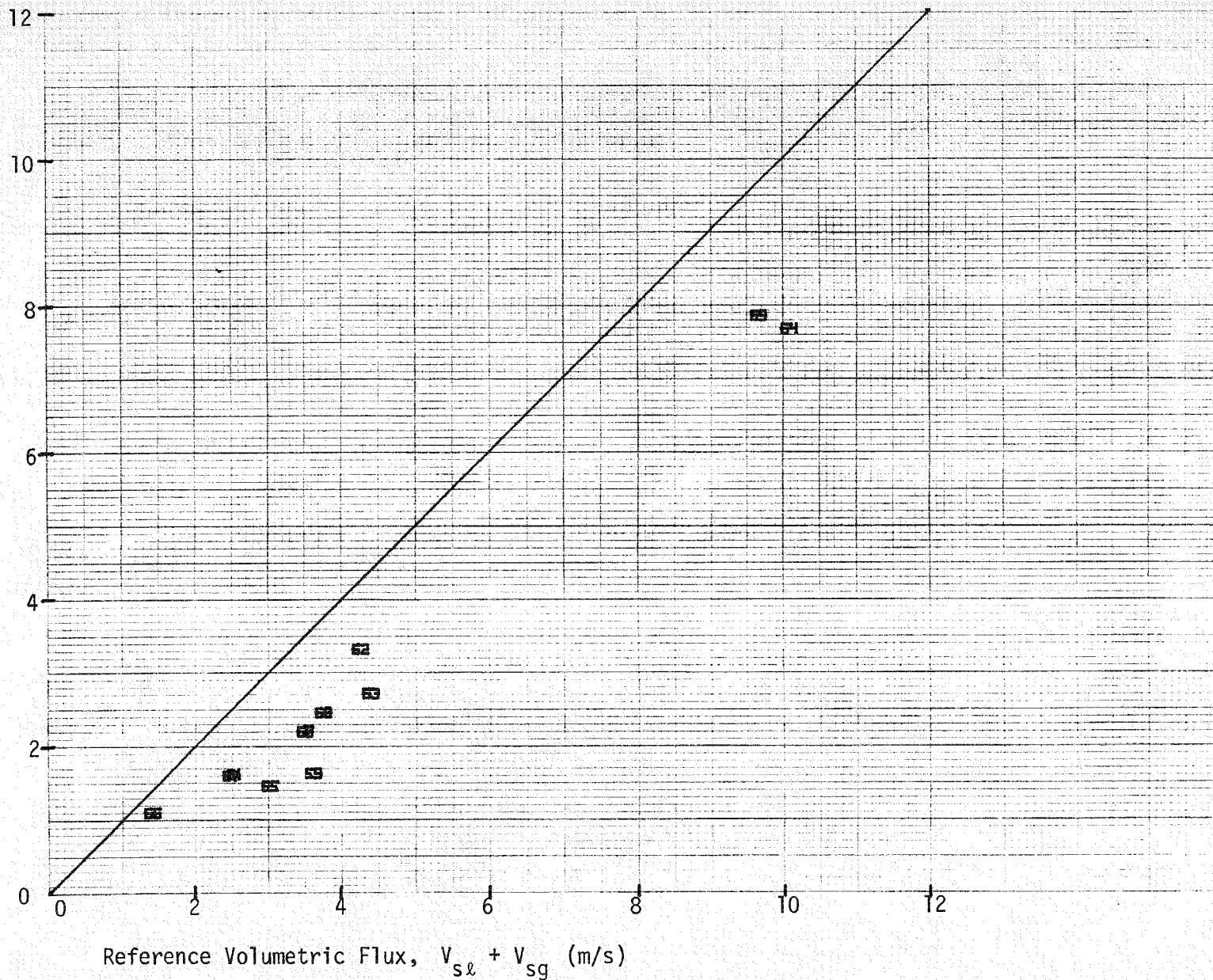


Figure 6.5 The Velocities Measured by Turbine at Various Volumetric Fluxes

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Velocity Calculated from Drag Disc and Densitometer Measurements

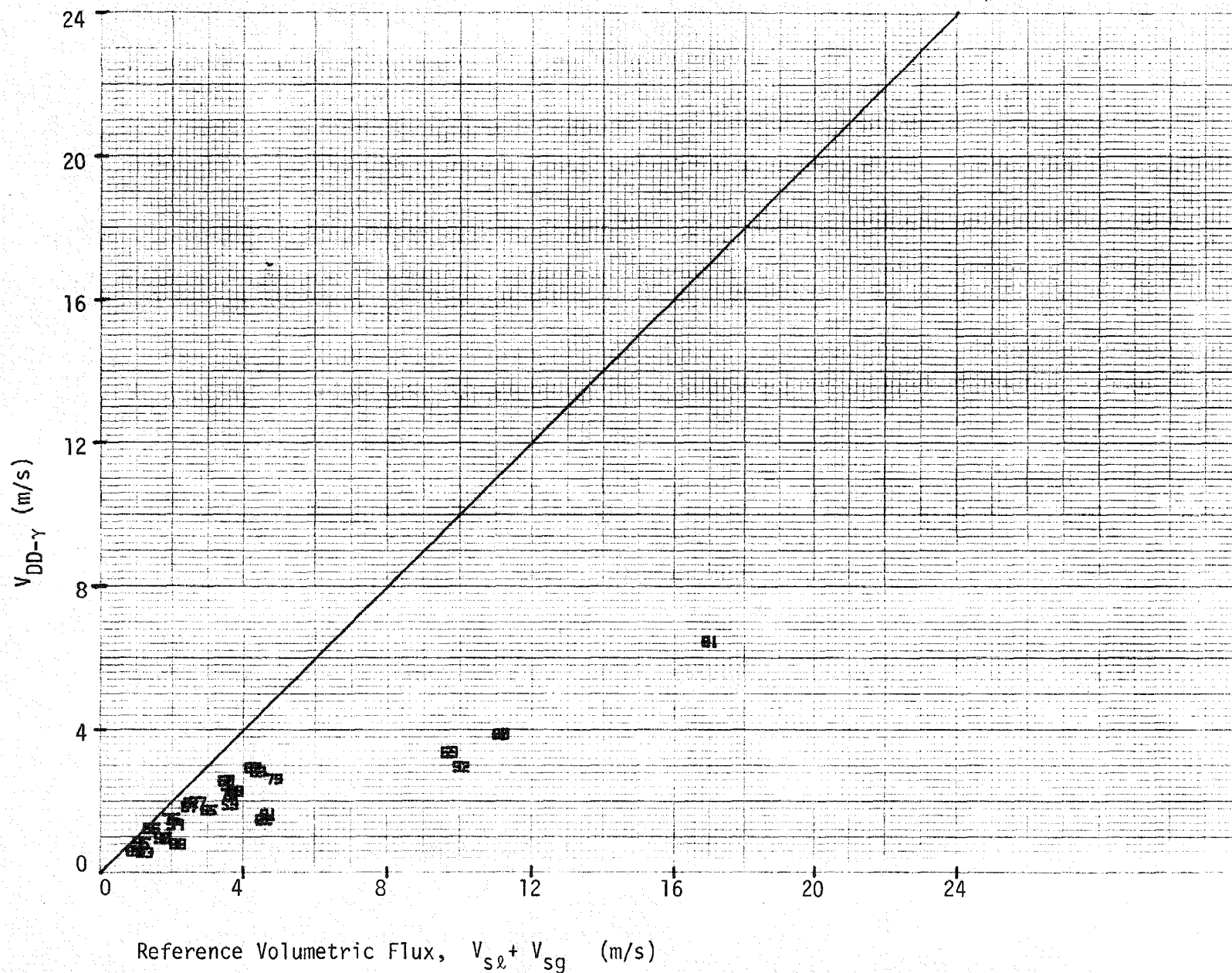


Figure 6.6 The Velocities Calculated from Drag Disc and Densitometer Measurements at Different Reference Volumetric Fluxes

Table 6.7
ERROR CALCULATIONS

PHASE II - MODULAR DTT
3 INCH 15 BAR

RUN ID TSN	ALPHA GAMMA	GDOT-GDOT G-T REF (KG/M ² *S)	VT-(VSL+VSG) (M/S)
7059	0.16	-175.68	-1.96
7060	0.37	-162.06	-1.29
7061	0.19	-228.53	-0.91
7062	0.57	-108.71	-0.93
7063	0.52	-203.56	-1.66
7064			-2.42
7065	0.39	-183.41	-1.55
7066	0.09	-107.19	-0.31
7067	0.41	-154.50	-0.88
7068	0.60	-110.51	-1.29
7069	0.78	660.48	-1.83
7076	0.15		
7077	0.35		
7078	0.49		
7079	0.63		
7080	0.71		
7081	0.80		
7082	0.68		
7083	0.08		
7088	0.44		
7089	0.14		
7090	0.38		
7091	0.66		
7092	0.75		
7093	0.57		
7094	0.41		
7095	0.04		

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$G_{\gamma-T} - G_{ref}$ (kg/m²s)

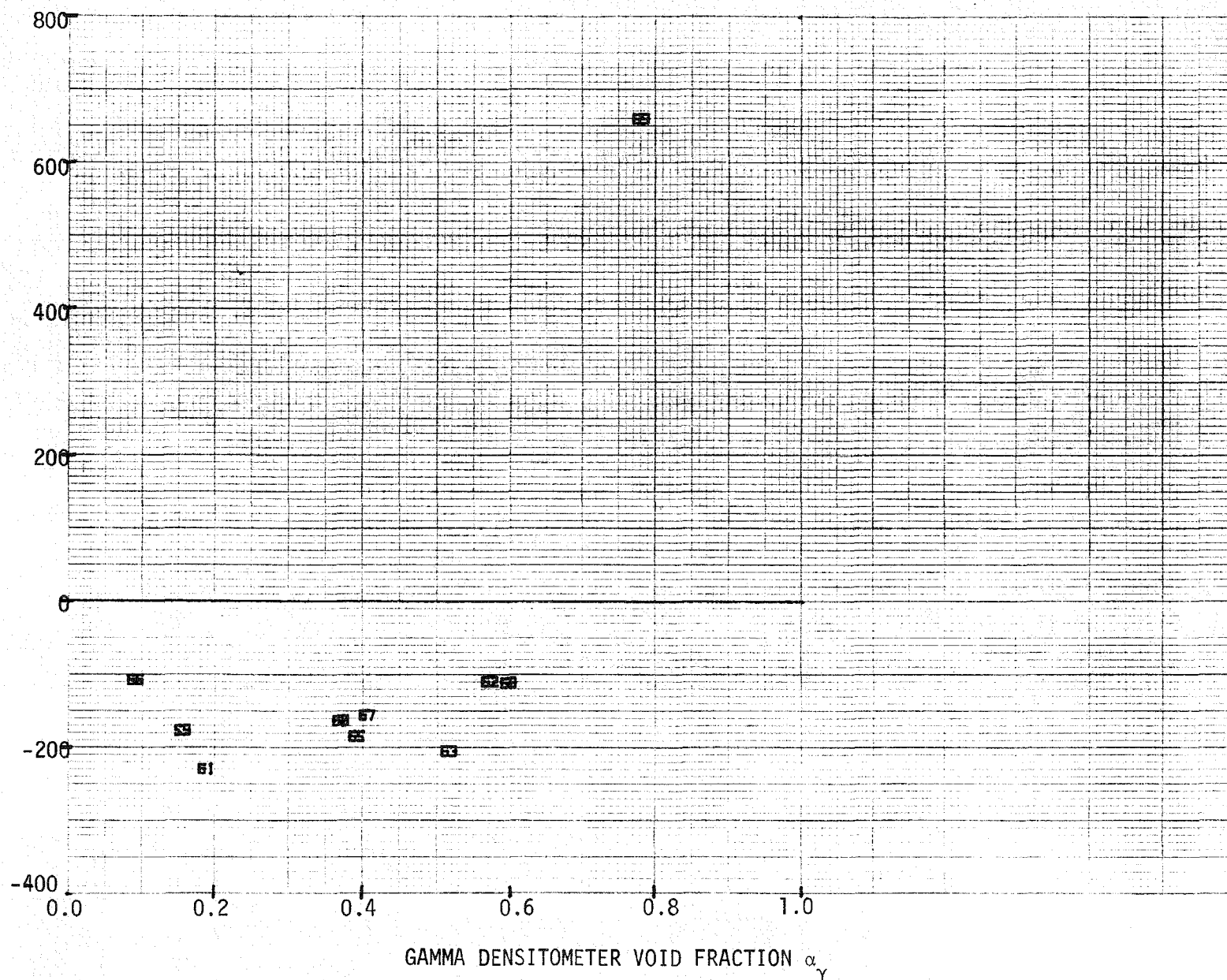


Figure 6.8 Error in Gamma Densitometer - Turbine Mass Flow Calculation

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$T - (V_{sg} + V_{sg})$ (m/s)

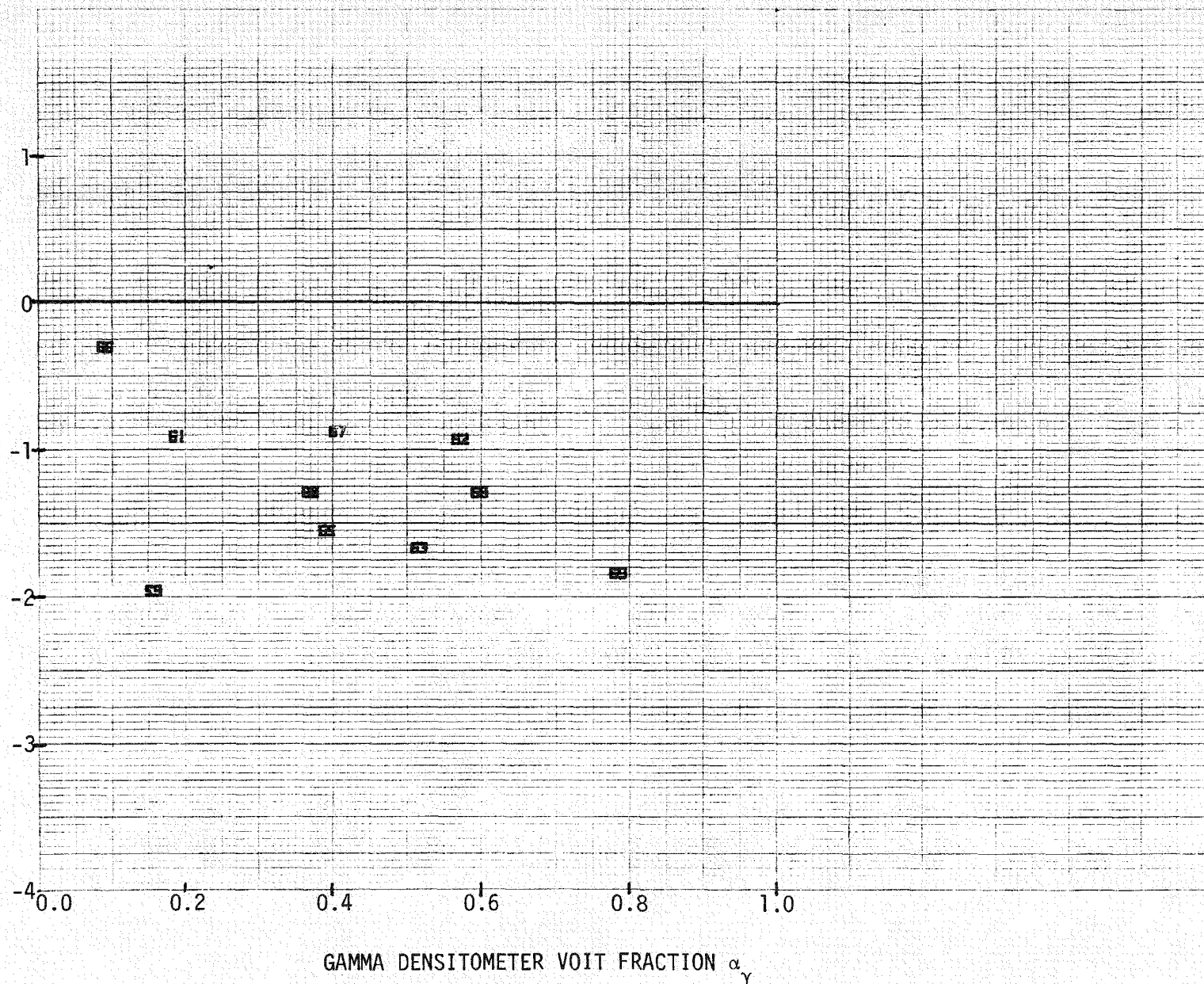


Figure 6.9 Error in Turbine Velocity

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Table 6.8

SINGLE INSTRUMENT CALCULATIONS

PHASE II - MODULAR DTT
3 INCH 15 BAR

RUN ID	LEN GAMMA	AVG REF	GDOT/(VSL+VSG) REF	DRAG DISK	(GDOT)X(VSL+VSG) REF	(SUM MW/ ALPHA)/AREA
TSN	(KG/M ³)		(KG/M ³)	(KG/M ³ S ²)	(KG/M ³ S ²)	(KG/M ³ S ²)
7059	736.26		382.32	2659	4913.72	2705.26
7060	550.91		393.47	3619	4748.63	3426.13
7061	704.83		540.07	2675	3437.86	2659.45
7062	375.96		319.47	3233	5721.67	4886.96
7063	423.50		308.74	3365	5887.92	4328.16
7064			111.87	3472	11348.29	
7065	533.51		319.14	1630	2866.52	1757.76
7066	788.62		690.77	1205	1344.26	1193.43
7067	520.75		397.88	1753	2423.51	1866.94
7068	354.10		261.55	1832	3631.06	2727.22
7069	194.91		89.66	2205	8373.49	4105.88
7076	732.12		588.40	1648	2276.58	1844.02
7077	558.83		427.07	2177	3117.96	2399.97
7078	443.22		323.89	2168	4107.16	3027.15
7079	330.00		231.38	2264	5364.41	3803.53
7080	256.54		106.58	3840	13103.22	5970.53
7081	180.40		68.96	7501	19841.78	8631.98
7082	284.58		149.76	620	3050.15	1667.40
7083	793.25		557.69	250	824.63	593.93
7088	491.65		264.26	309	1196.69	663.60
7089	745.78		617.01	259	533.65	444.60
7090	536.62		340.51	499	986.40	636.72
7091	302.40		139.89	786	3031.37	1492.88
7092	222.90		72.15	1939	7202.09	2813.52
7093	376.10		155.25		395.94	389.27
7094	509.90		355.26	915	1511.96	1065.20
7095	826.30		641.59	567	810.57	647.12

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Density Measured by Gamma Densitometer (beam length averaged),

$\bar{\rho}$ (kg/m³)

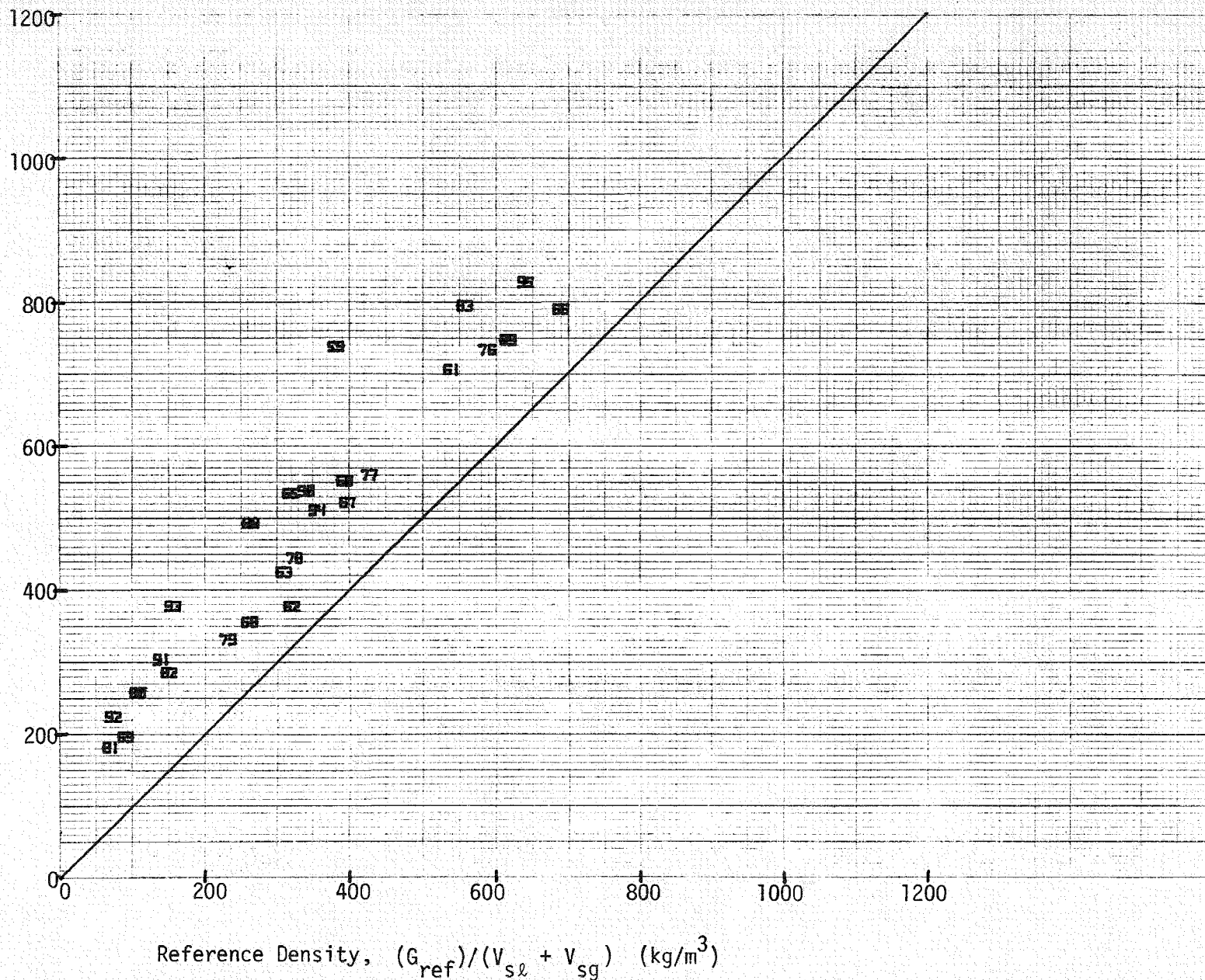


Figure 6.10 Density Comparisons

LTR LO-00-80-113
ENCLOSURE

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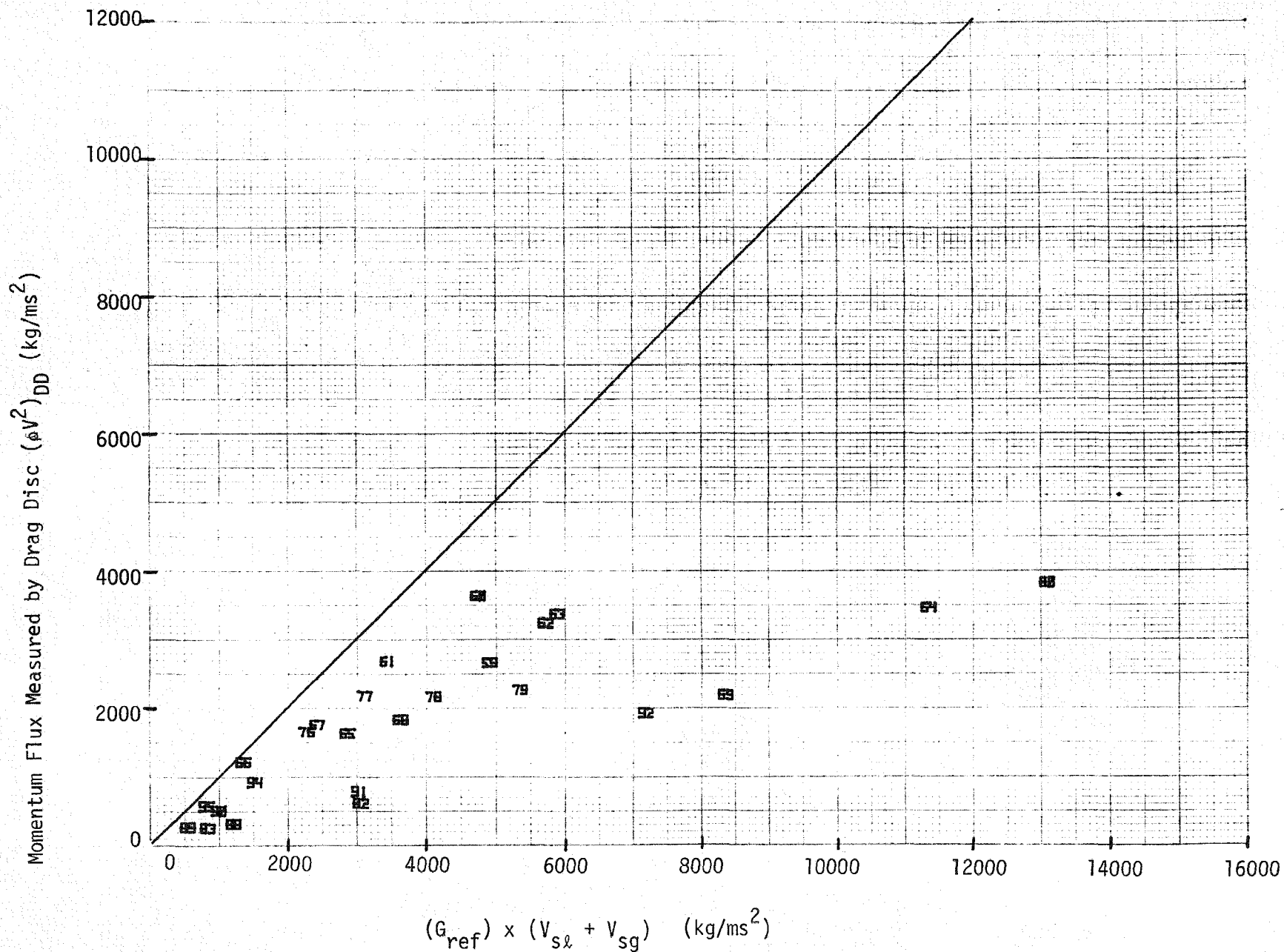
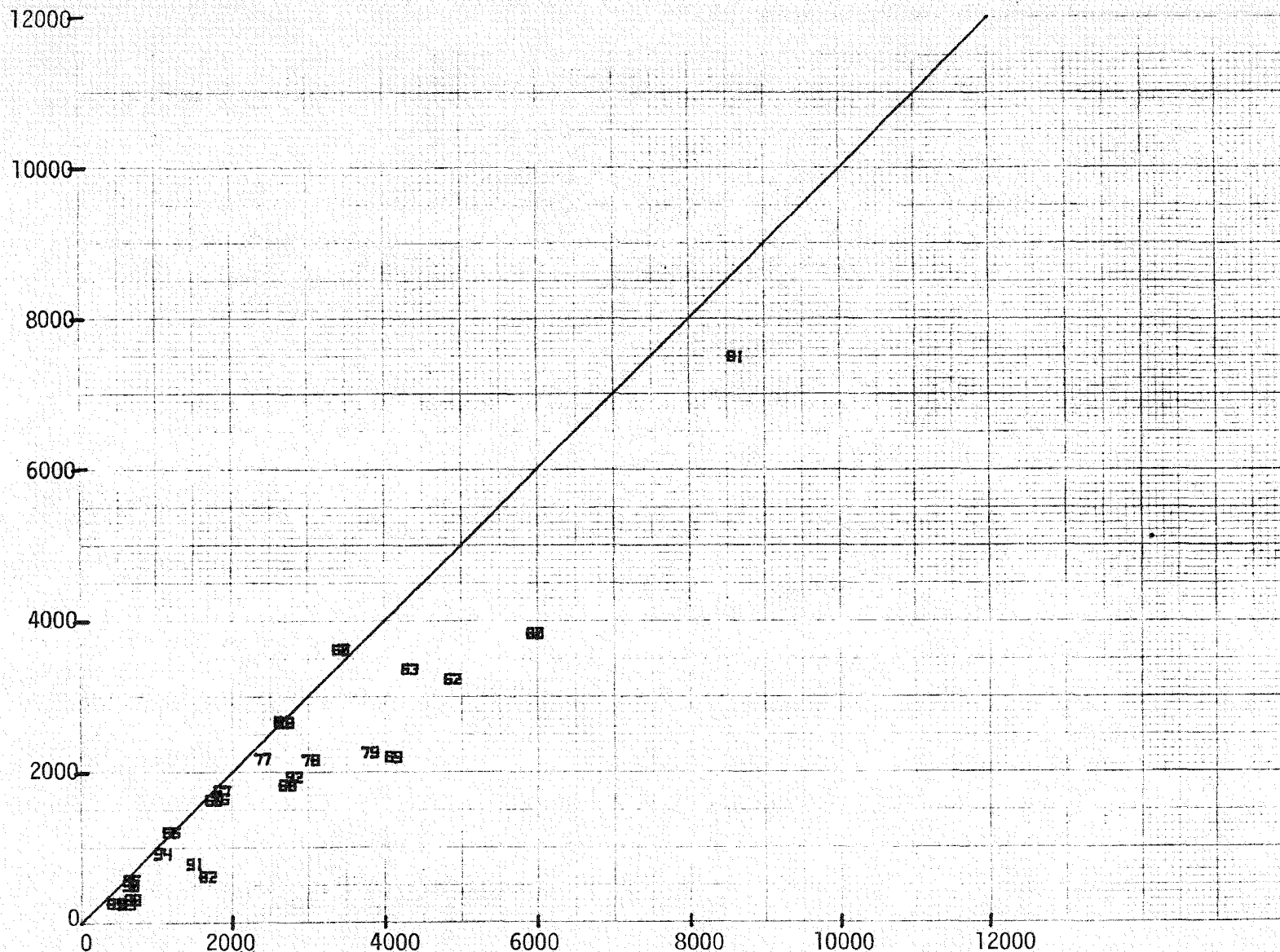


Figure 6.11 Momentum Flux Comparisons

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KFK 2784

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Momentum Flux Measured by Drag Disc, $(\rho v^2)_{DD} (\text{kg/ms}^2)$



Reference Momentum Flux using Densitometer; Measured Void Fraction
 $(G_g V_{sg} / \alpha_Y) + G_l V_{sl} / (1 - \alpha_Y) (\text{kg/ms}^2)$

Figure 6.12 Drag Disk Momentum Flux Comparisons

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 KFK 2784

REV. 2.1.1

7.

THREE INCH STEAM WATER 40 BAR

MODULAR DTT

Table 7.1

PRIMARY ENGINEERING UNIT DATA

7-1 FLUID: STEAM - WATER INSIDE DIAMETER= 0.06665 M
 PIPE SIZE= 3 INCH SCHEDULE 160 TURB. DIA.= 0.0381 M
 NOMINAL PRESSURE= 40 BARS PIPE AREA= 0.0034887 M²

PHASE II - MODULAR DTT

PHASE II - MODULAR DTT														
		FLOW RATES						GAMMA DENSITOMETER				RADIOTRACER		
		STEAM		WATER		TURB.	DRAG	A BEAM	B BEAM	C BEAM	SCAN	VELOCITIES		
RUN	PRESS.	TEMP.	SUP-VEL	MASS	SUP-VEL	MASS	VEL	DISK	UPPER	MIDDLE	LOWER	DENS	STEAM	WATER
ID	TSN (BARS)	(DEG C)	(M/S)	(KG/S)	(M/S)	(KG/S)	(M/S)	M* ² +2)	M* ³	M* ³	M* ³	M* ³	(M/S)	(M/S)
													(AT GAMMA DENS)	
7035	42.3	253.5	2.05	0.152	0.059	3.457	2.68	2236	336	401	603	289		
7036	42.7	254.9	1.92	0.146	1.317	3.667	2.49	2545	369	436	652	339		
7037	42.1	253.5	1.28	0.096	1.390	3.756	1.95	2248	486	525	758	400		
7038	42.0	253.5	0.03	0.002	1.390	3.878	1.46	1819	697	712	894	658		
7039	42.0	253.5	1.57	0.117	1.310	3.633	2.34	2237	376	464	623	-		
7040	42.3	253.5	2.99	0.222	1.260	3.498	3.87	2311	257	371	494	-		

dash indicates error in data
 blank indicates no data

LTR LO-00-80-113
 KFK 2784

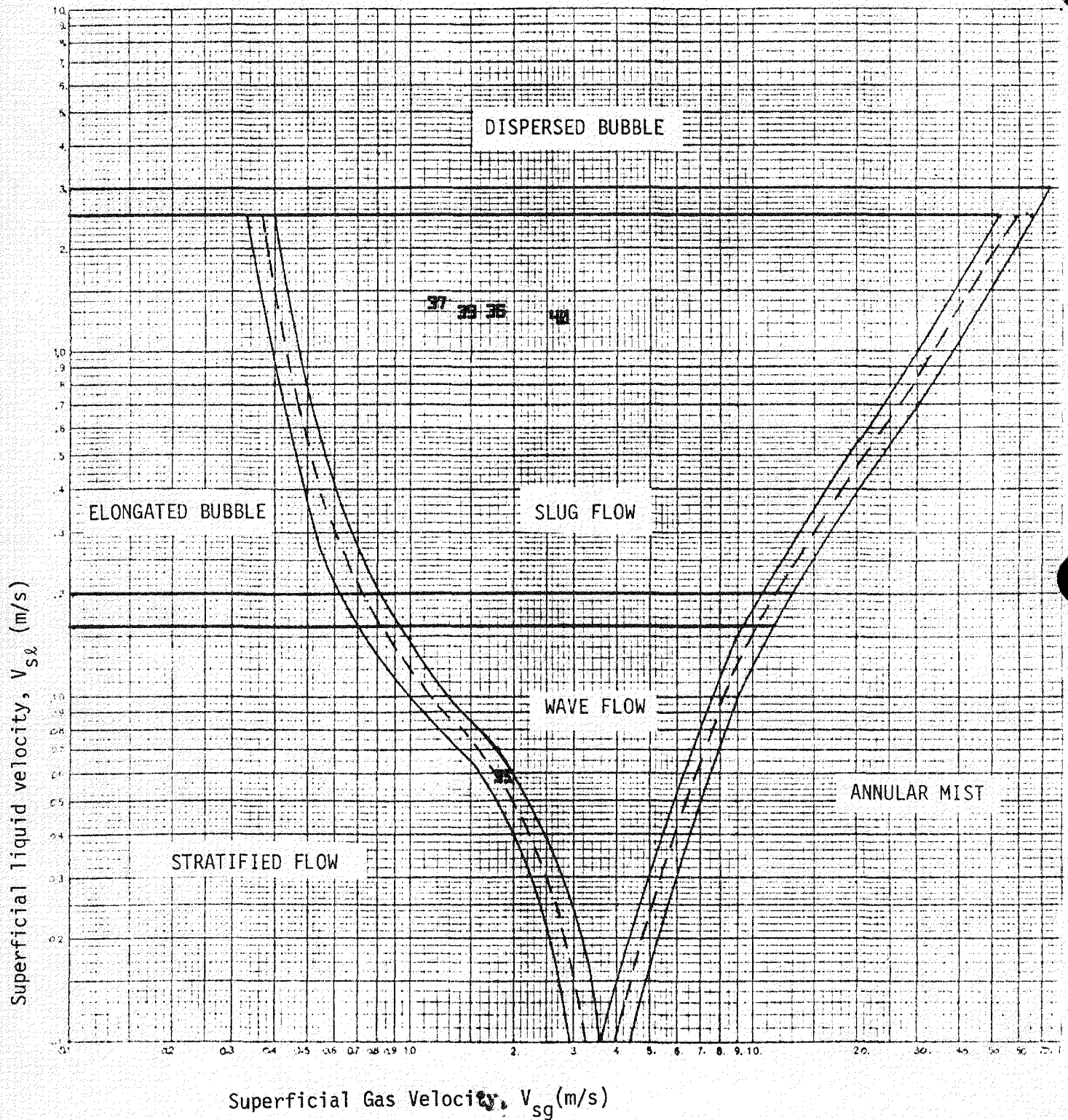


Figure 7.1a Govier and Aziz Flow Regime Map

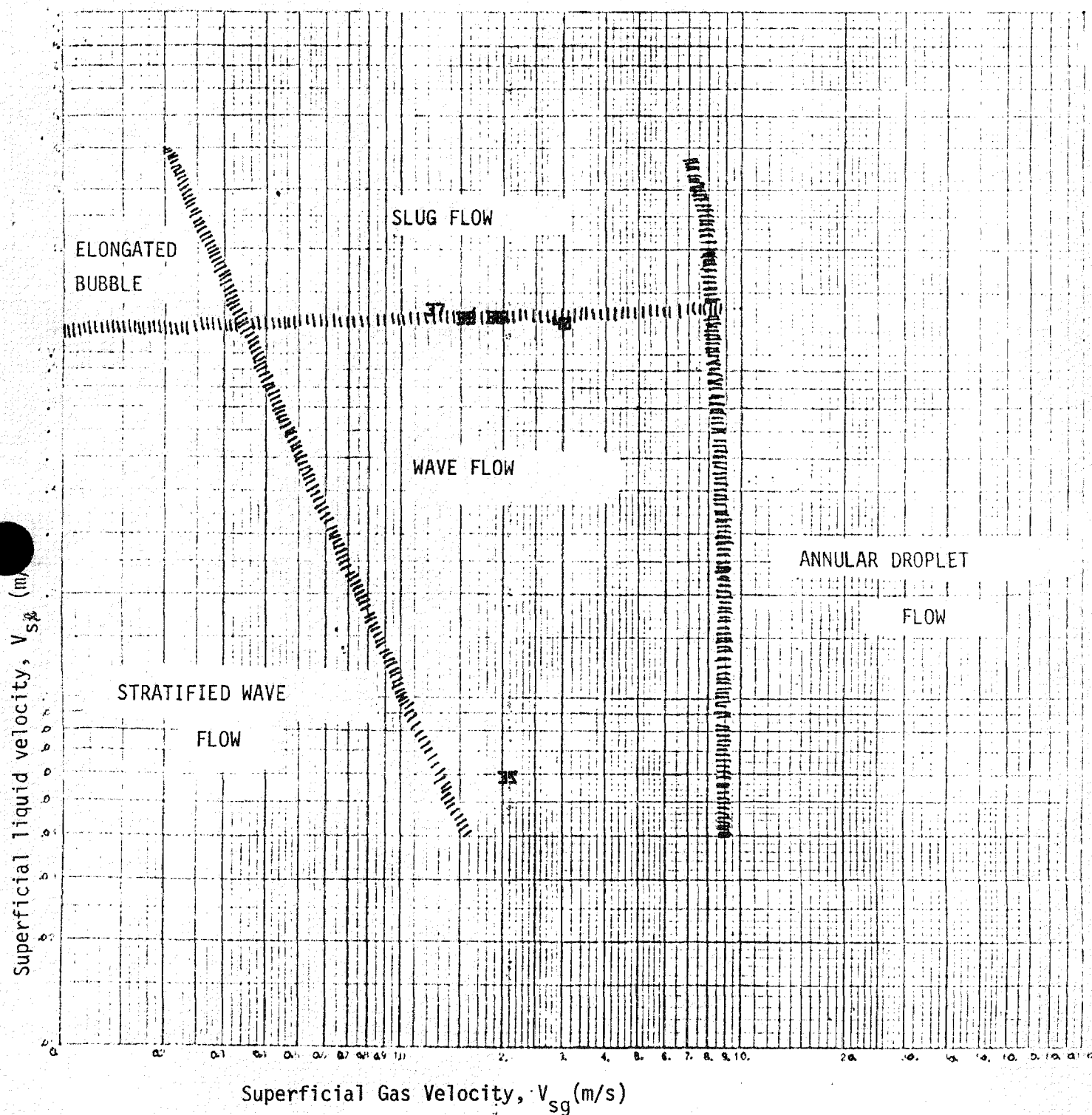


Figure 7.1b Impedance Probe Flow Regime Map

Table 7.2

MASS FLOW RATE COMPARISONS

PHASE II - MODULAR DTT
3 INCH 40 BAR

RUN ID	GDOT REF	GDOT G-T	GDOT G-DD	GDOT T-DD
TSN (KG/M ² *S)	(KG/M ² *S)	(KG/M ² *S)	(KG/M ² *S)	(KG/M ² *S)
7035	1034.423	1158.222	982.841	834.017
7036	1092.895	1171.778	1094.157	1021.678
7037	1104.073	1116.749	1134.932	1153.412
7038	1112.098	1105.042	1171.751	1242.486
7039	1074.837	1115.248	1031.668	954.352
7040	1066.239	1410.307	917.820	597.312

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Table 7.3
TOTAL VELOCITY COMPARISONS

PHASE II - MODULAR DTT
3 INCH 40 BAR

RUN ID TSN	VSL+VSG (M/S)	TURB. VEL (M/S)	VEL. DD-G (M/S)
7035	2.109	2.681	2.275
7036	3.237	2.491	2.326
7037	2.670	1.949	1.981
7038	1.417	1.464	1.552
7039	2.880	2.344	2.168
7040	4.250	3.869	2.518

Table 7.4
VOID FRACTION COMPARISONS

PHASE II - MODULAR DTT
3 INCH 40 BAR

RUN ID TSN	DENSITIES (KG/M ³)			VAPOR FRACTIONS			
	VERT AVG GAMMA	LEN AVG GAMMA	SCAN DENS	ALPHA GAMMA (LEN)	ALPHA SCAN DENS	ALPHA THERMO	RADIOTRACER VAPOR FRACTION STEAM WATER
7035	427.46	432.01	289.05	0.47	0.65	0.97	
7036	465.59	470.40	338.82	0.41	0.59	0.59	
7037	568.36	572.99	400.27	0.28	0.51	0.48	
7038	751.47	754.81	658.35	0.05	0.17	0.02	
7039	471.60	475.79		0.41		0.55	
7040	360.48	364.51		0.55		0.70	

Table 7.5

PHASE VELOCITY COMPARISONS

PHASE II - MODULAR DTT
3 INCH 40 BAR

RUN ID TSN	V GAS G DENS (M/S)	V GAS RADIO (M/S)	V LIQ. G DENS (M/S)	V LIQ. RADIO (M/S)	SLIP G DENS	SLIP RADIO
7035	4.408		0.110		39.970	
7036	4.632		2.249		2.059	
7037	4.544		1.935		2.348	
7038	0.597		1.456		0.410	
7039	3.845		2.214		1.736	
7040	5.408		2.818		1.919	

Table 7.6
FLOW REGIME COMPARISONS

AFN 2784

RUN ID TSN	From Govier & Aziz Flow Regime Map	From Gamma Densitometer		From Flow Regime	Reference Densitometer Interface Location(%)*
		Flow Regime	Interface Location(%)*		
7035	Wave Flow		53.44		
7036	Slug Flow		62.15		
7037	-		81.58		
7038	Slug Flow		120.61		
7039	Slug Flow		62.15		
7040	Slug Flow		42.95		

*Pipe Empty: 0.0 cm liquid level is -37.47%
Pipe Full: 6.665 cm liquid level is 137.47%
Bottom of DTT Housing: 1.4275 cm liquid level is 0.0%
Top of DTT Housing: 5.2375 cm liquid level is 100.0%

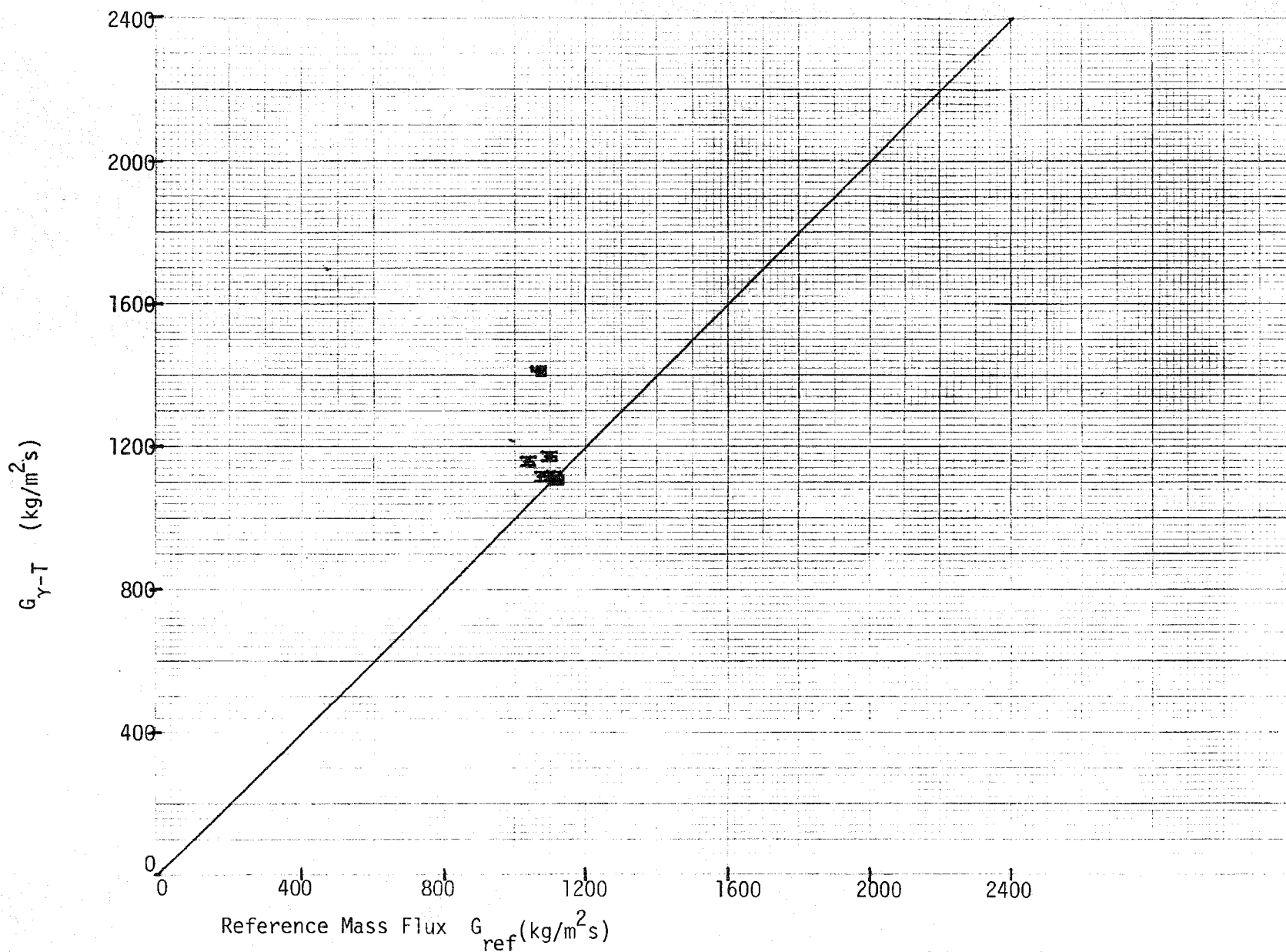


Figure 7.2 Mass Fluxes Calculated from Gamma Densitometer and Turbine Measurements at Different Reference Values

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Mass Flux Calculated from Densitometer and Drag Disc Measurements

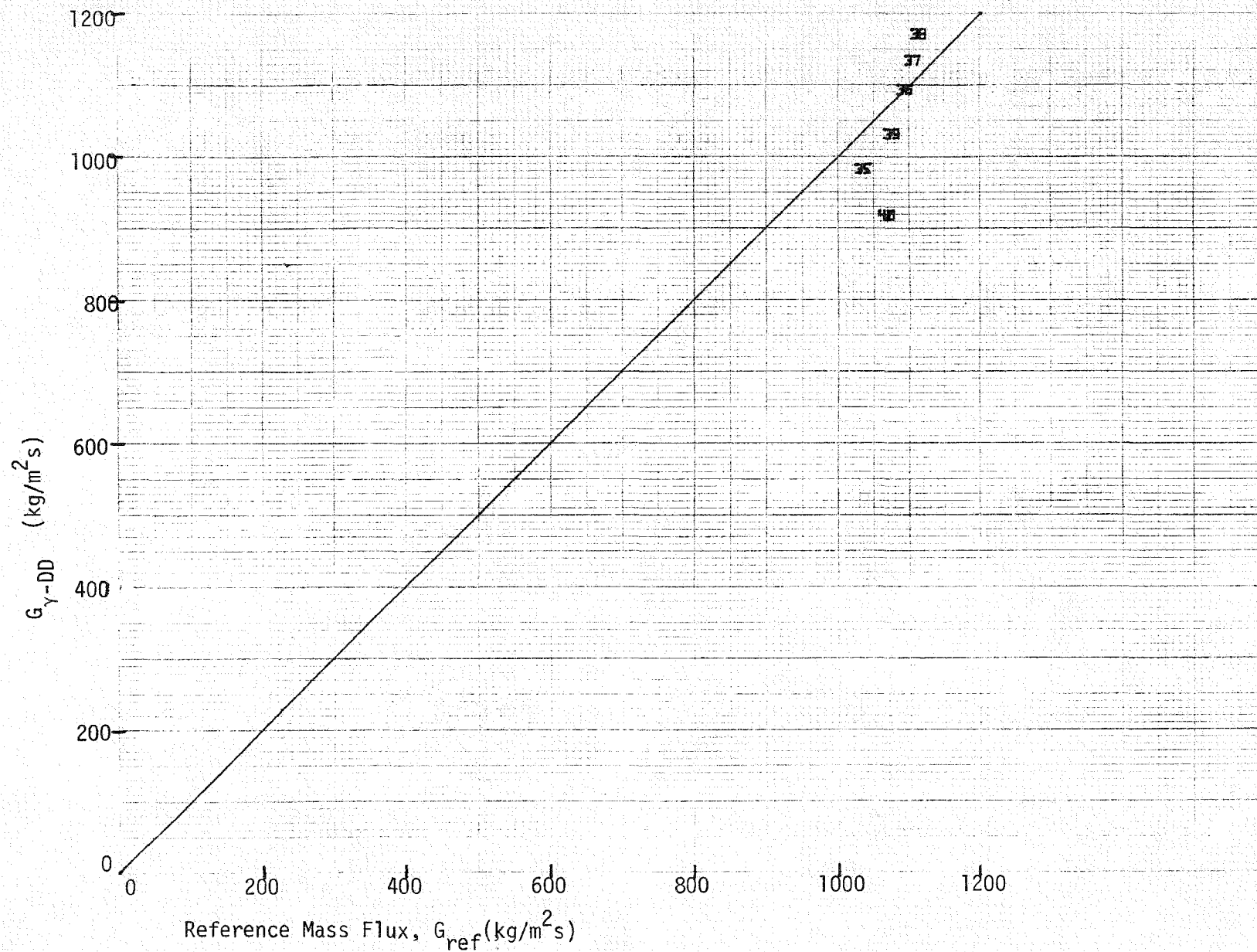


Figure 7.3 Mass Fluxes Calculated from Gamma Densitometer and Turbine Measurements at Different Reference Values

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Mass Flux Calculated from Turbine and Drag Disc Measurements

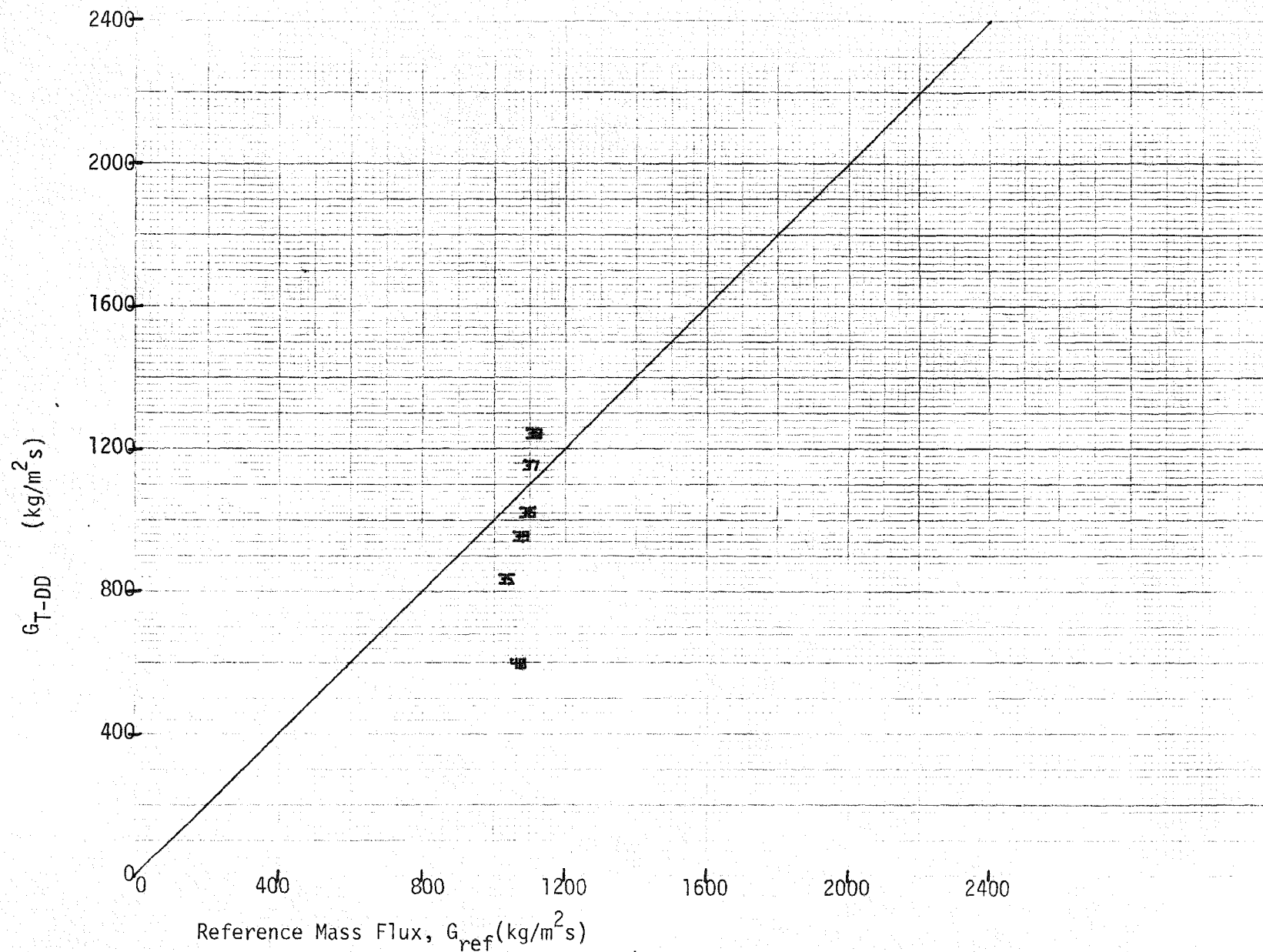


Figure 7.4 Mass Fluxes Calculated from Turbine and Drag Disc Measurements at Different Reference Values

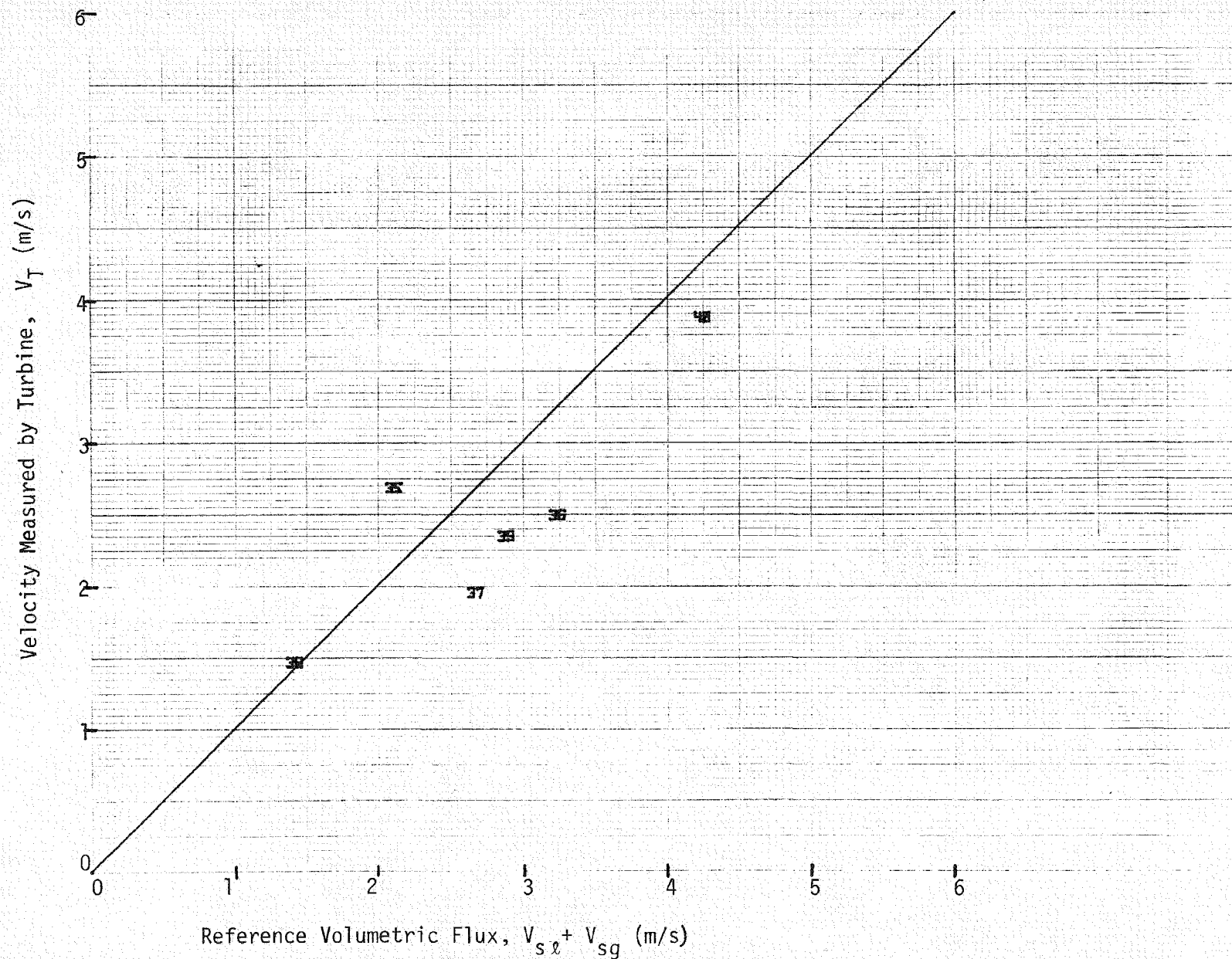


Figure 7.5 The Velocities Measured by Turbine at Various Volumetric Fluxes

ε_{L-Z}
 Velocity Calculated from Drag Disc and Densitometer
 Measurements, $V_{DD-\gamma}$ (m/s)

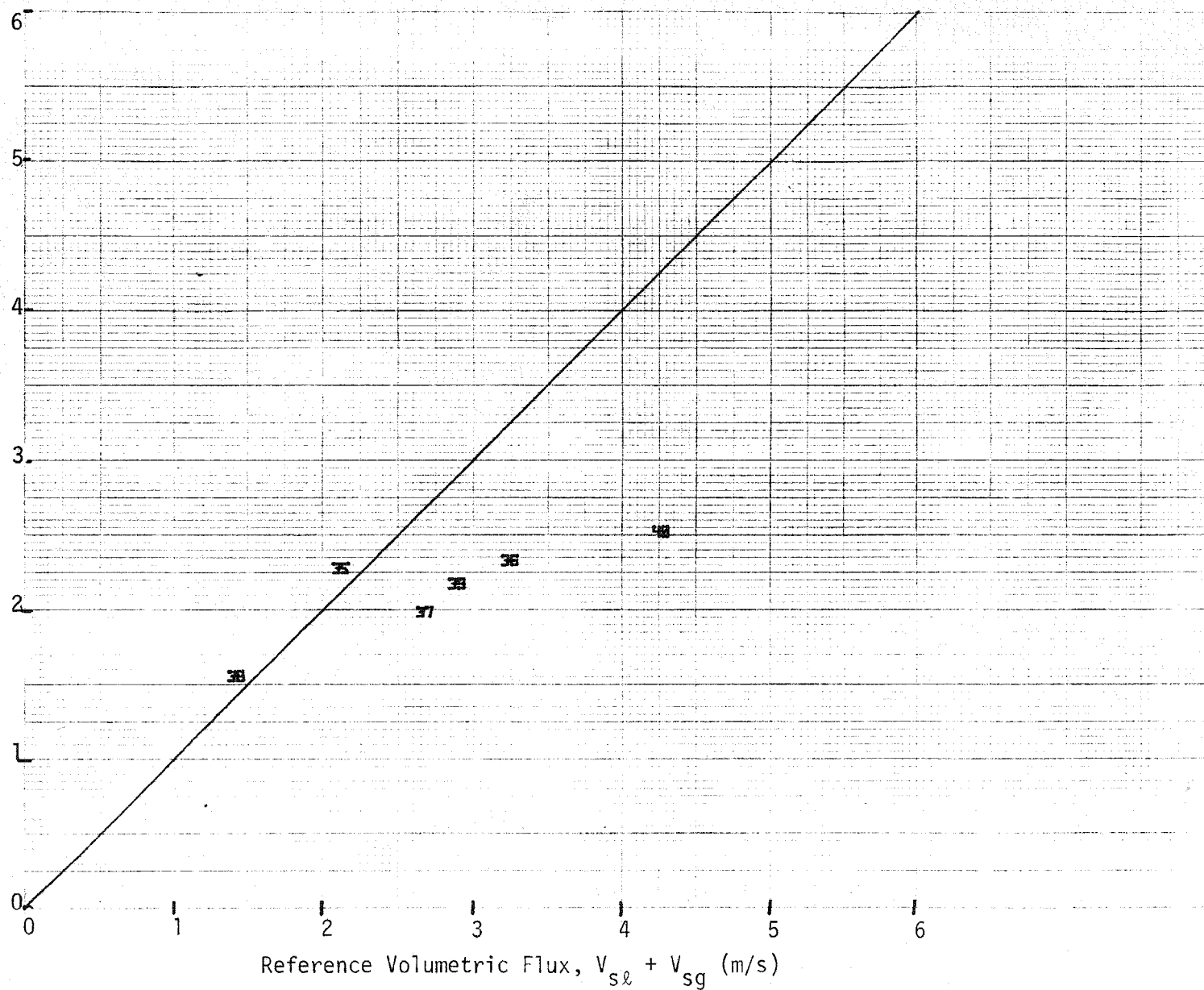


Figure 7.6 The Velocities Calculated from Drag Disc and Densitometer
 Measurements at Different Reference Volumetric Fluxes

Table 7.7
ERROR CALCULATIONS

PHASE II - MODULAR DTT
3 INCH 40 BAR

RUN ID TSN	ALPHA GAMMA	GDOT-GDOT G-T REF (KG/M ² *S)	VT-(VSL+VSG) (M/S)
7035	0.47	123.80	0.57
7036	0.41	78.88	-0.75
7037	0.28	12.68	-0.72
7038	0.05	-7.06	0.05
7039	0.41	40.41	-0.54
7040	0.55	344.07	-0.38

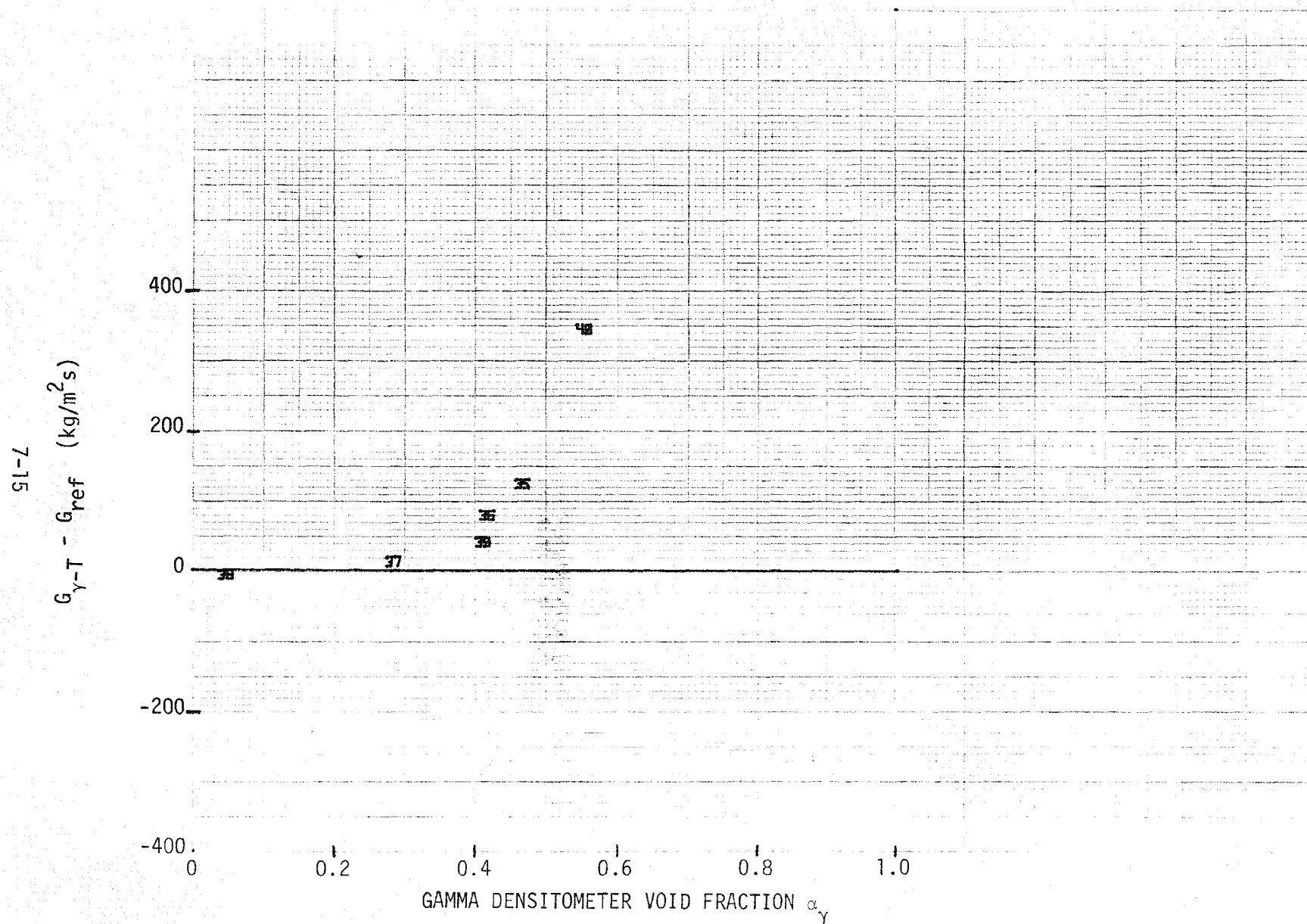


Figure 7.8 Error in Gamma Densitometer - Turbine Mass Flow Calculation

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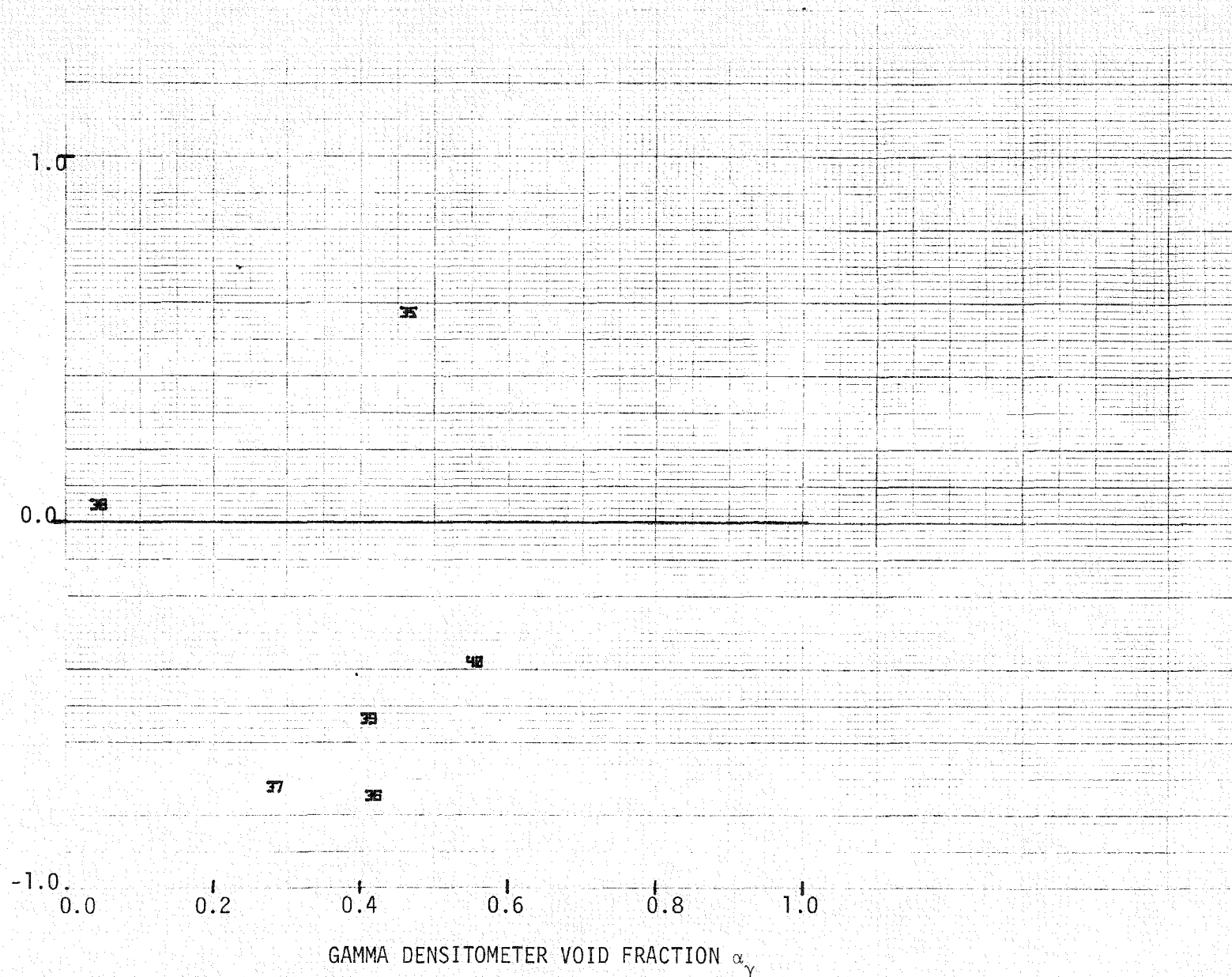


Figure 7.9 Error in Turbine Velocity

LIR LO-00-80-113
KFN 2784

Table 7.8
SINGLE INSTRUMENT CALCULATIONS

PHASE II - MODULAR DTT
3 INCH 40 BAR

RUN ID	LEN GAMMA	AVG REF	GDOT/(VSL+VSG) REF (KG/M ³)	DRAG DISK (KG/M*S ²)	(GDOT)X(VSL+VSG) REF (KG/M*S ²)	(SUM MV/ ALPHA)/AREA (KG/M*S ²)
7035	432.01		490.48	2236	2181.60	301.70
7036	470.40		337.63	2545	3537.70	2557.76
7037	572.99		413.51	2248	2947.87	2207.99
7038	754.81		784.83	1819	1575.84	1618.57
7039	475.79		373.21	2237	3095.53	2434.56
7040	364.51		250.88	2311	4531.51	3170.12

81-2
Density Measured by Gamma Densitometer (Beam length averaged),
 $\bar{\rho}$ (kg/m³)

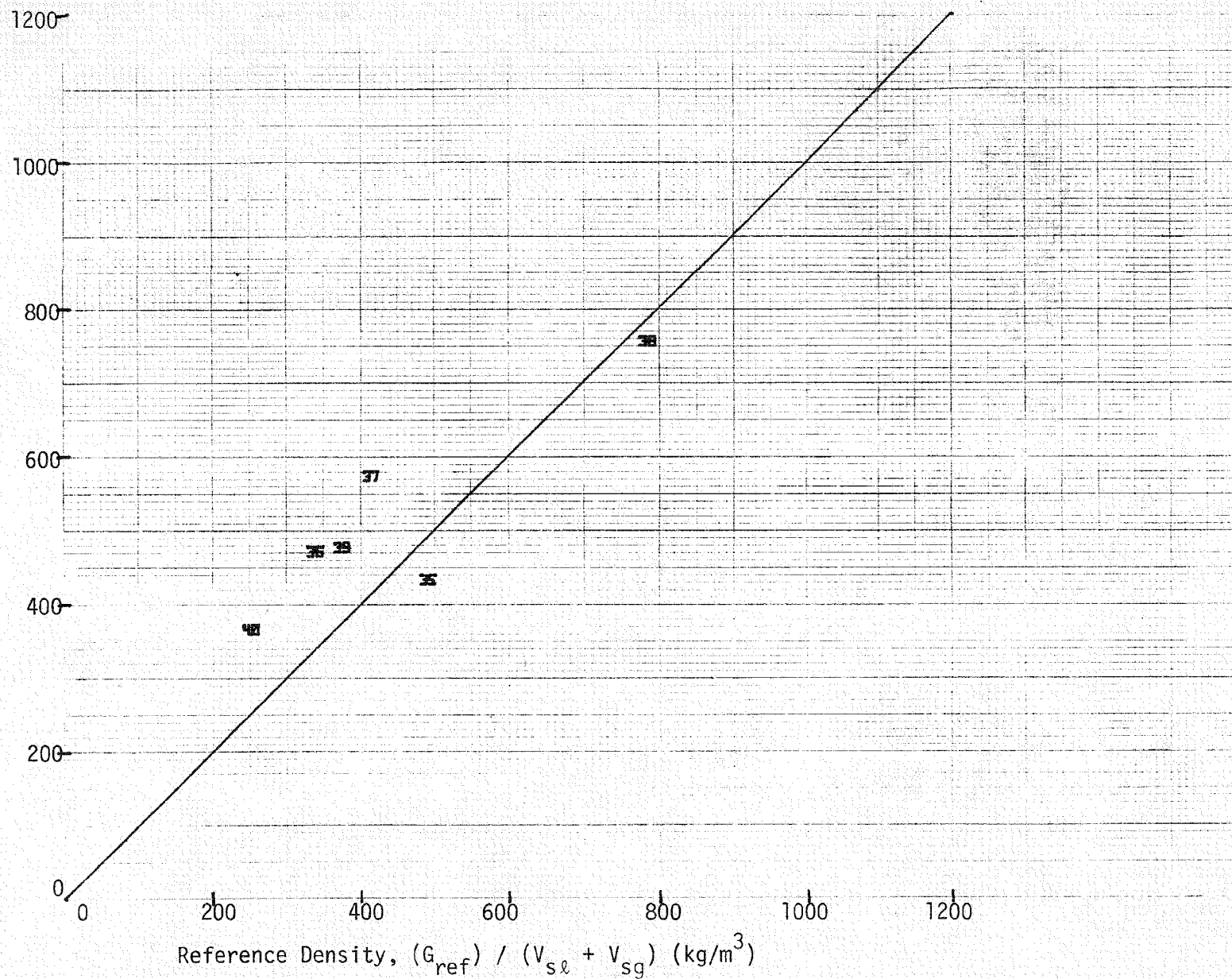


Figure 7.10 Density Comparisons

LTR L0-00-80-113
REV 2786

61-7

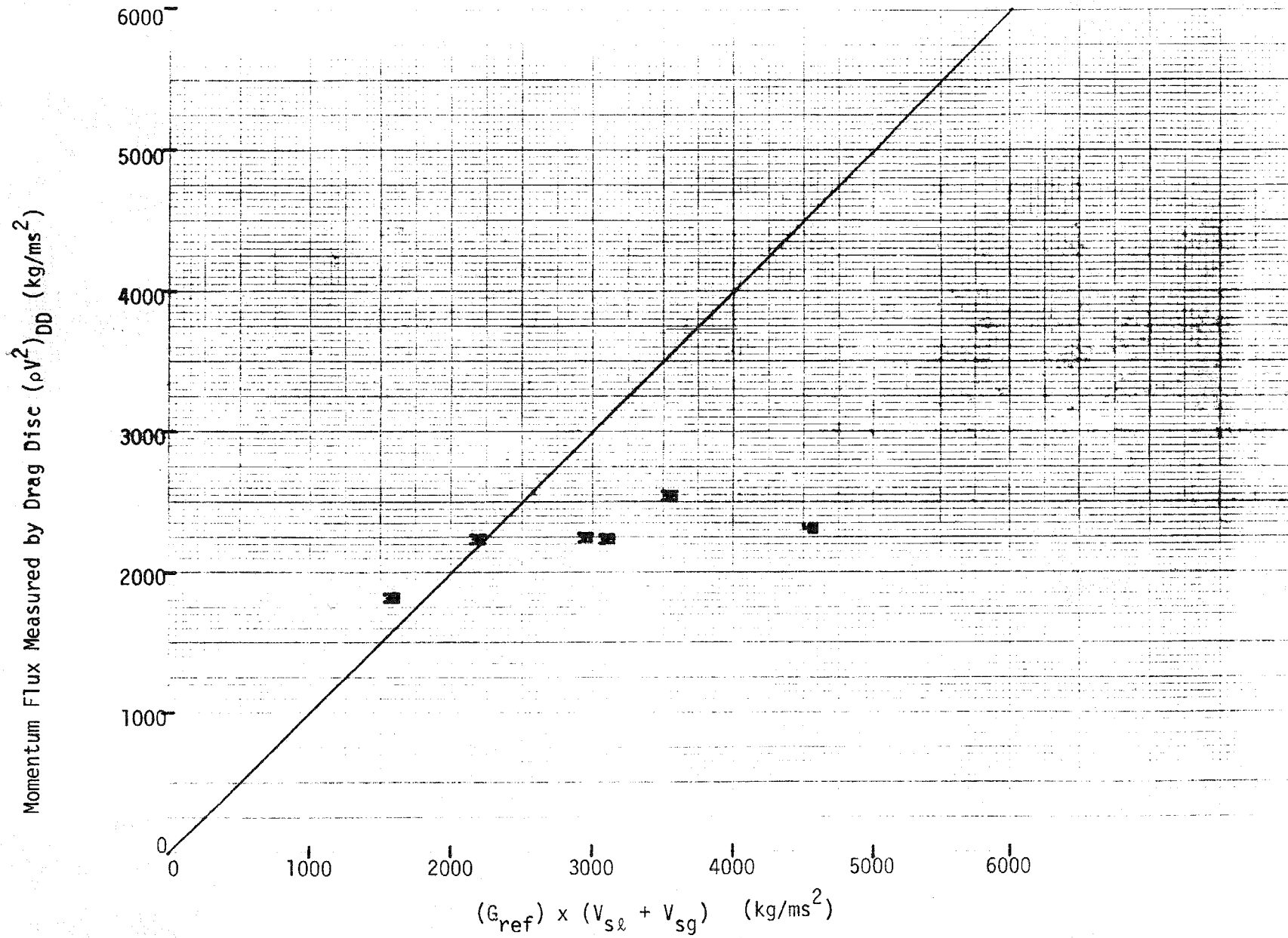


Figure 7.11 Momentum Flux Comparisons

LIR LO-00-80-113
RTV 2784

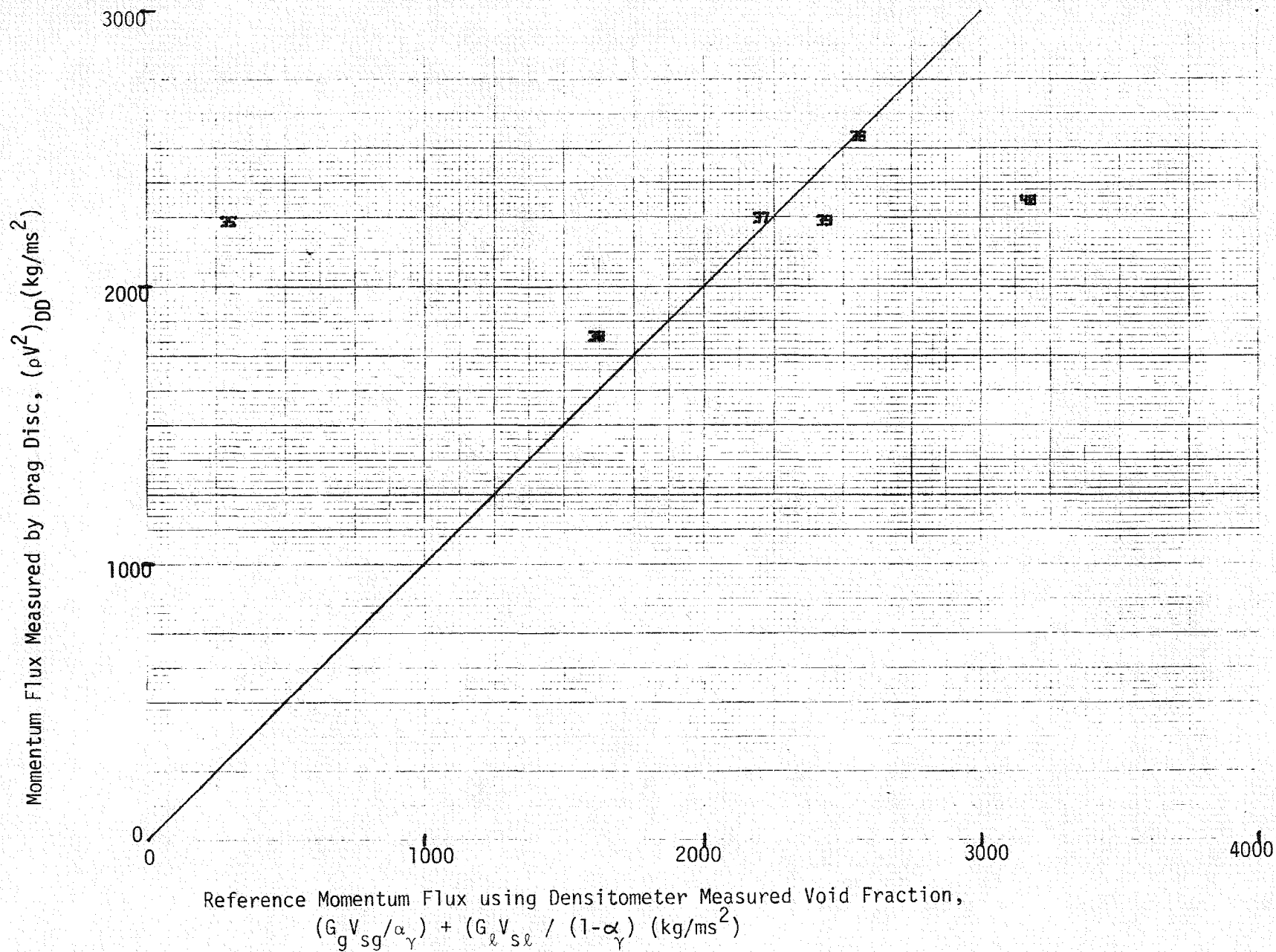


Figure 7.12 Drag Disc Momentum Flux Comparison

8. THREE INCH STEAM-WATER 15 BARS

PLENUM DTT

Table 8.1

PRIMARY ENGINEERING UNIT DATA

FLUID: STEAM - WATER
 PIPE SIZE= 3 INCH SCHEDULE 160
 NOMINAL PRESSURE= 15 BARS

INSIDE DIAMETER= 0.06665 M
 TURB. DIA.= 0.0381 M
 PIPE AREA= 0.0034889 M²

PHASE II - PLENUM DTT

RUN ID	PRESS. (BARS)	TEMP. (DEG C)	FLOW RATES		TURB. DISK		DRAG (KG/ M* ² S ²)	GAMMA DENSITOMETER			SCAN DENS (KG/ M ³)	RADIOTRACER VELOCITIES	
			STEAM SUP-VEL MASS (M/S) (KG/S)	WATER SUP-VEL MASS (M/S) (KG/S)	UPPER	MIDDLE		LOWER	STEAM	WATER			
7102	18.3	207.5	2.13	0.067	1.580	4.721	2.43	2593	377	452	774	414	
7103	16.9	202.5	0.52	0.014	1.599	4.807	1.62	2048	752	804	941	766	
7104	17.5	202.9	1.51	0.048	1.584	4.746	2.16	2441	460	543	872	476	
7105	16.4	199.3	3.24	0.091	1.565	4.713	3.08	3166	309	383	665	-	
7106	17.7	202.5	8.72	0.274	1.361	4.072	7.19	4117	161	247	525	234	

dash indicates error in data
 blank indicates no data

KEK 2784
 LIR LO-00-80-113

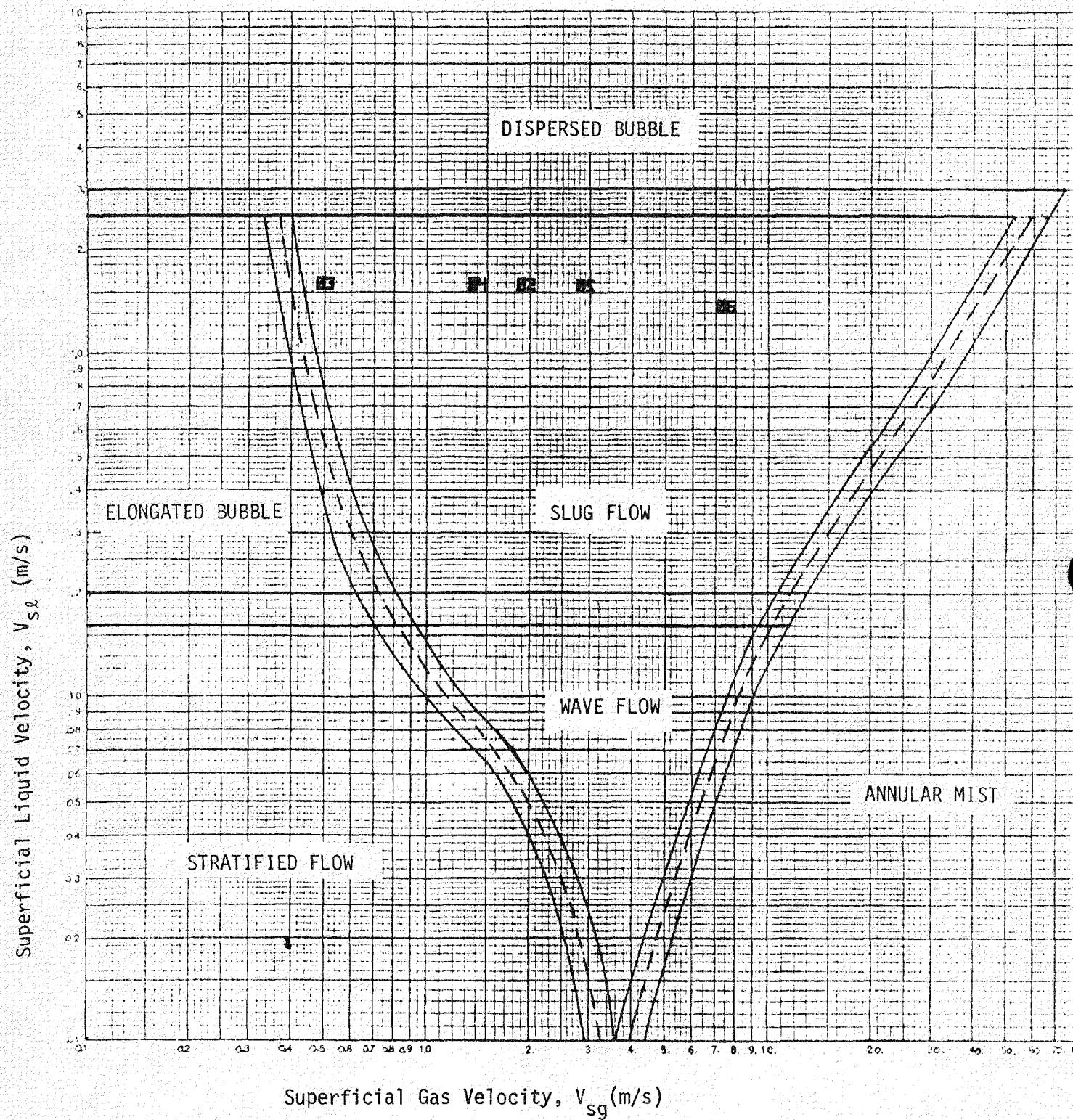


Figure 8.1a Govier and Aziz Flow Regime Map

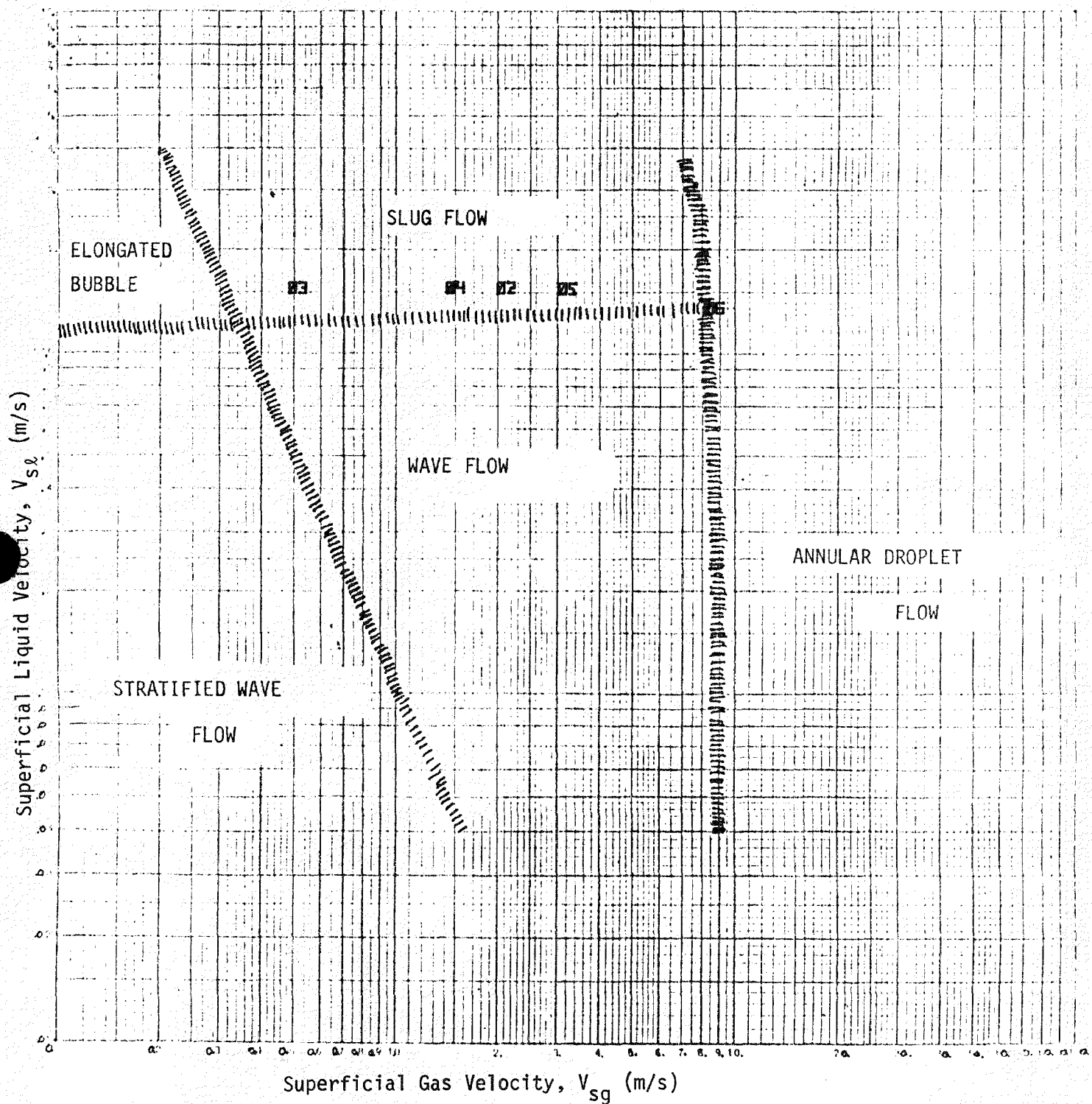


Figure 8.1b Impedance Probe Flow Regime Map

Table 8.2

MASS FLOW RATE COMPARISONS

PHASE II - PLENUM DTT
3 INCH 15 BAR

RUN ID	GDOT REF	GDOT G-T	GDOT G-DD	GDOT T-DD
TSN (KG/M ² *S)	(KG/M ² *S)	(KG/M ² *S)	(KG/M ² *S)	(KG/M ² *S)
7102	1372.352	1241.526	1151.951	1068.838
7103	1381.811	1333.395	1297.935	1263.418
7104	1374.072	1299.640	1211.624	1129.570
7105	1376.938	1333.226	1169.904	1026.589
7106	1245.665	2093.602	1094.744	572.442

Table 8.3

TOTAL VELOCITY COMPARISONS

PHASE II - PLENUM DTT
3 INCH 15 BAR

RUN ID TSN	VSL+VSG (M/S)	TURB. VEL (M/S)	VEL. DD-G (M/S)
7102	3.712	2.426	2.251
7103	2.121	1.621	1.578
7104	3.097	2.161	2.015
7105	4.802	3.084	2.706
7106	10.082	7.192	3.761

Table 8.4
VOID FRACTION COMPARISONS

PHASE II - PLENUM DTT
3 INCH 15 BAR

RUN ID TSN	DENSITIES (KG/M ³)			VAPOR FRACTIONS			
	VERT AVG GAMMA	LEN AVG GAMMA	SCAN DENS	ALPHA GAMMA (LEN)	ALPHA SCAN DENS	ALPHA THERMO	RADIOTRACER VAPOR FRACTION STEAM WATER
7102	505.01	511.76	414.01	0.41	0.52	0.57	
7103	819.36	822.58	766.03	0.05	0.11	0.25	
7104	594.41	601.41	476.37	0.30	0.45	0.49	
7105	426.25	432.30		0.51		0.67	
7106	284.92	291.10	233.73	0.67	0.74	0.87	

Table 8.5

PHASE VELOCITY COMPARISONS

PHASE II - PLENUM DTT
3 INCH 15 BAR

RUN ID TSN	V GAS G DENS (M/S)	V GAS RADIO (M/S)	V LIQ. G DENS (M/S)	V LIQ. RADIO (M/S)	SLIP G DENS	SLIP RADIO
7102	5.225		2.669		1.958	
7103	10.834		1.680		6.449	
7104	4.964		2.279		2.178	
7105	6.404		3.164		2.024	
7106	13.044		4.106		3.177	

Table 8.6
FLOW REGIME COMPARISONS

KFK 2784

RUN ID TSN	From Govier & Aziz Flow Regime Map	From Gamma Densitometer		Reference From Densitometer	
		Flow Regime	Interface Location(%)*	Flow Regime	Interface Location(%)*
7102	Slug Flow		61.72		
7103	Slug Flow		120.61		
7104	Slug Flow		78.70		
7105	Slug Flow		49.07		
7106	Slug Flow		26.19		

*Pipe Empty: 0.0 cm liquid level is -37.47%
 Pipe Full: 6.665 cm liquid level is 137.47%
 Bottom of DTT Housing: 1.4275 cm liquid level is 0.0%
 Top of DTT Housing: 5.2375 cm liquid level is 100.0%

6-8

Mass Flux Calculated from Densitometer and Turbine Measurements,

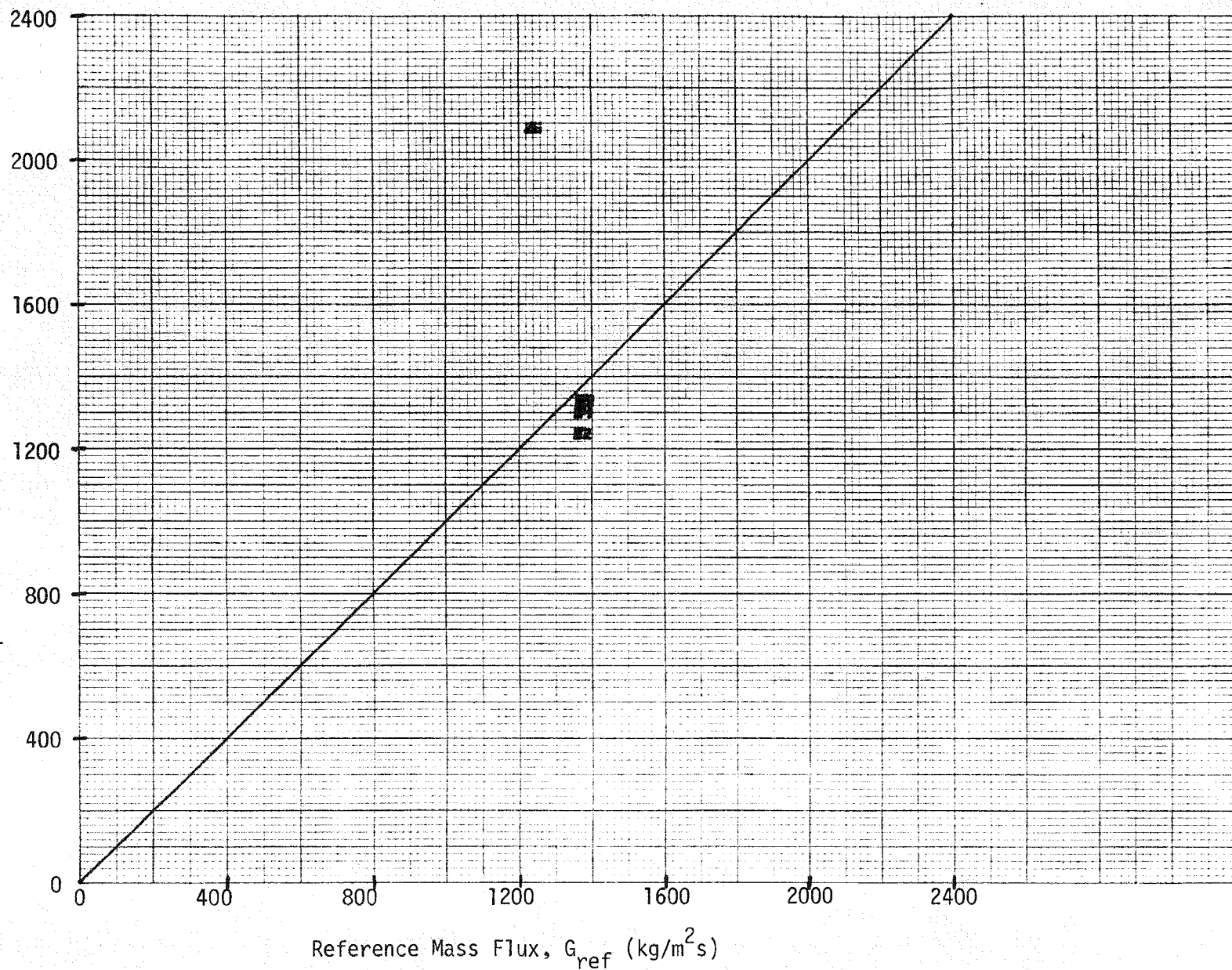
 $G_{\gamma-T}$ ($\text{kg/m}^2\text{s}$)

Figure 8.2 Mass Fluxes Calculated from Gamma Densitometer and Turbine Measurements at Different Reference Values

KFK 2703

LIR LO-CO-80-113

01-8

Mass Flux Calculated from Densitometer and Drag Disc Measurements,

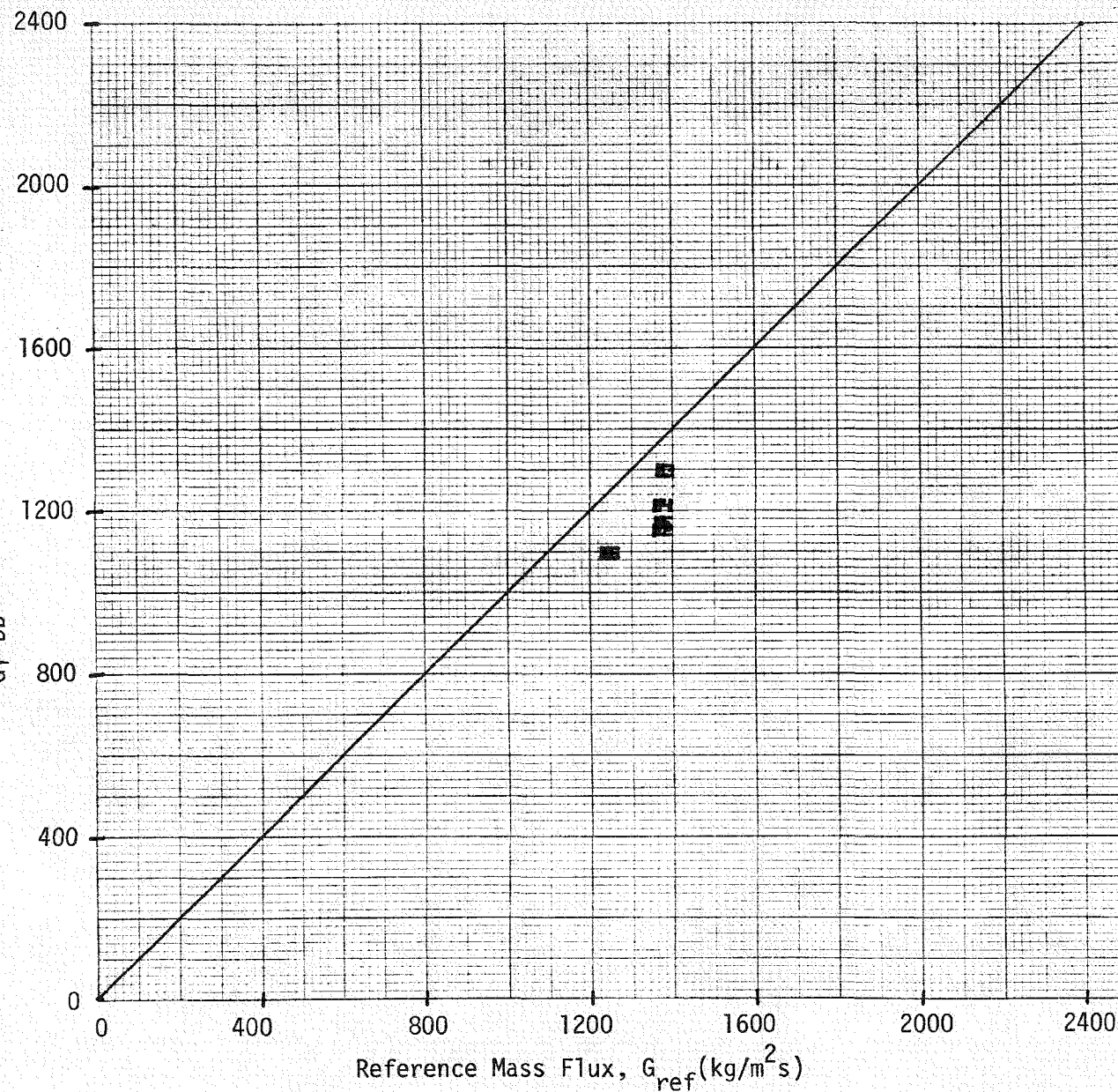
 $G_{Y-DD} (kg/m^2s)$ 

Figure 8.3 Mass Fluxes Calculated from Gamma Densitometer and Drag Disc Measurements at Different Reference Values

LTR LO-00-80-113
KFK 2784

Mass Flux Calculated from Turbine and Drag Disc Measurements,

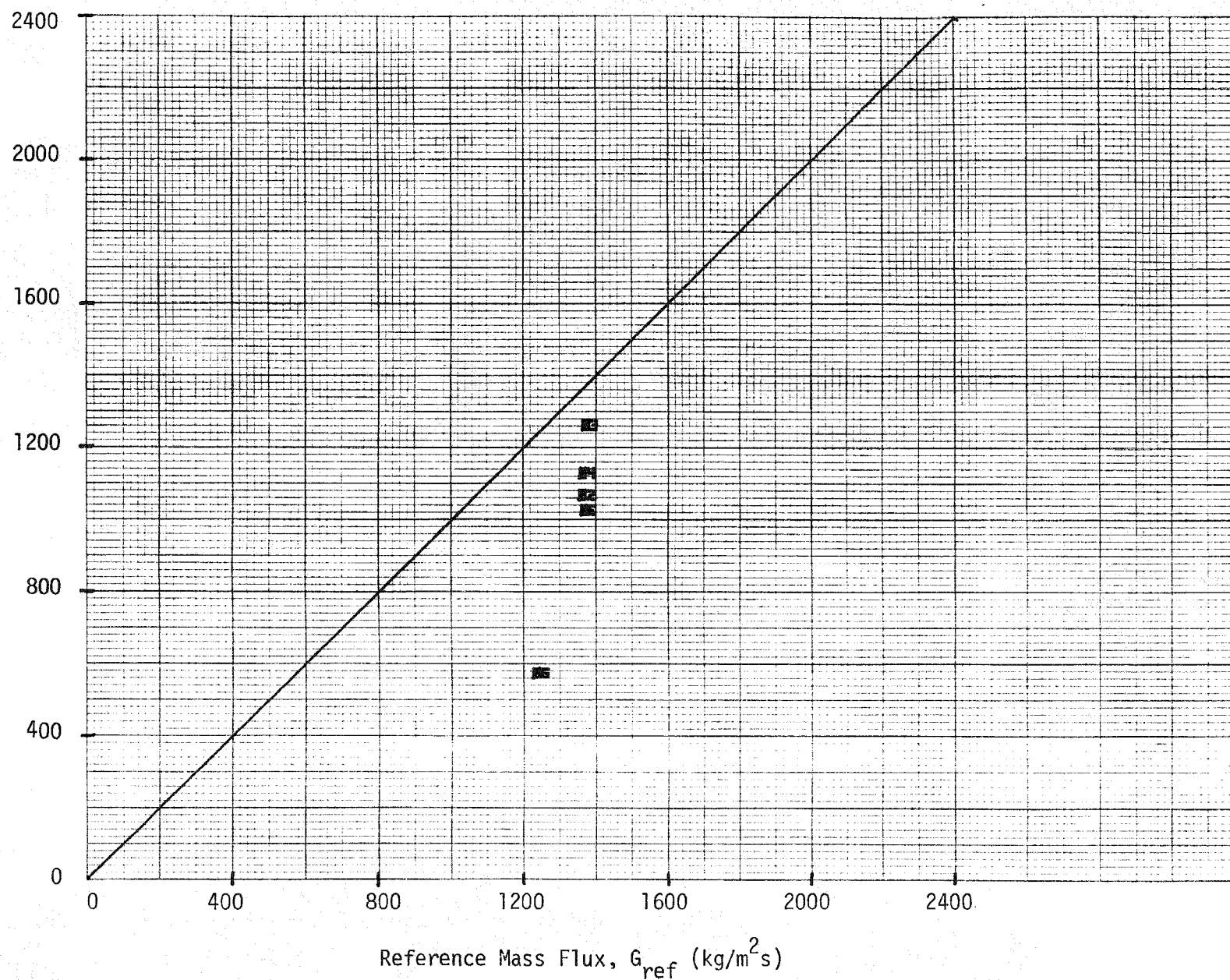
 G_{T-DD} ($\text{kg/m}^2\text{s}$)

Figure 8.4 Mass Fluxes Calculated from Turbine and Drag Disc Measurements at Different Reference Values

8-12

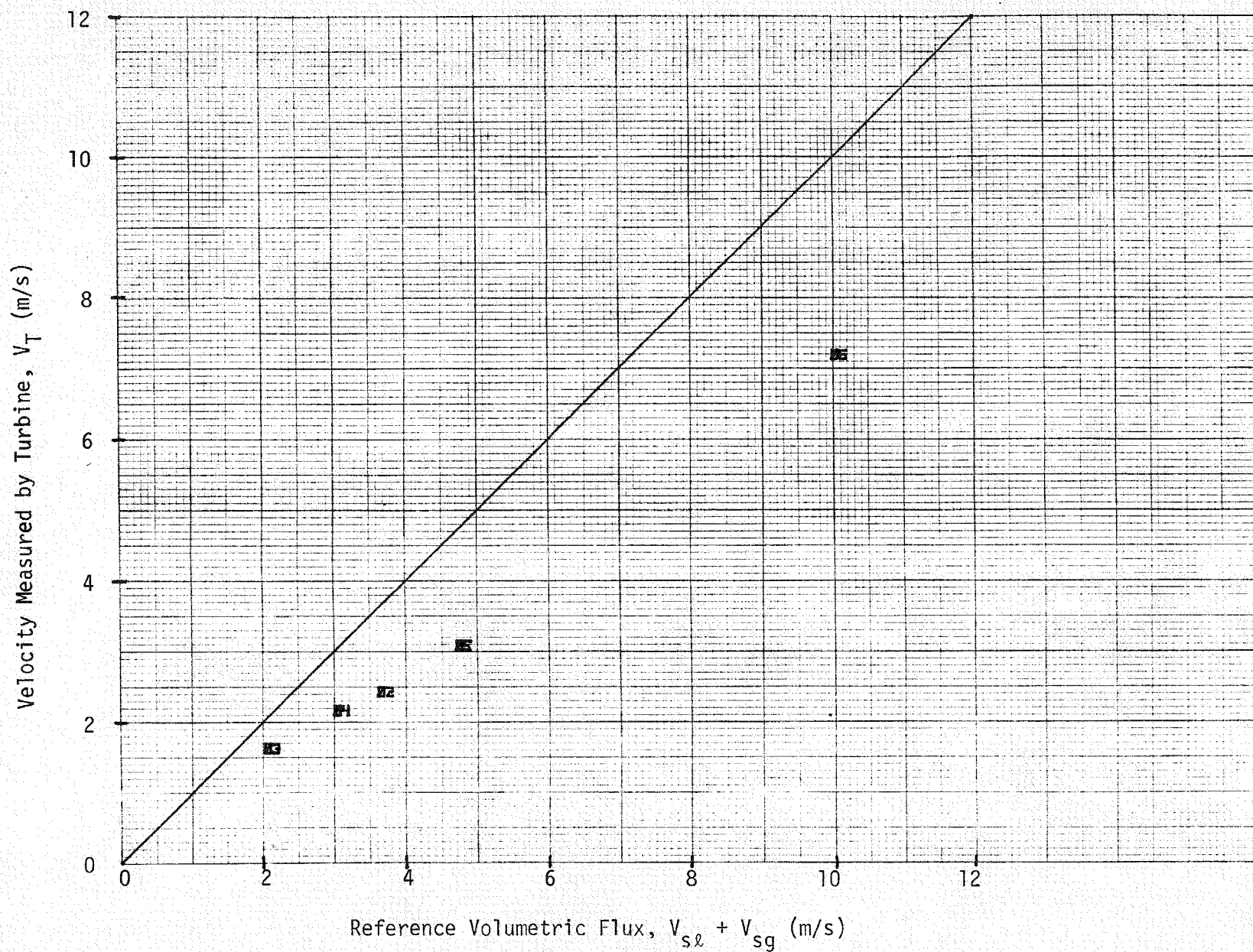


Figure 8.5 The Velocities Measured by Turbine at Various Volumetric Fluxes

LTR L0-00-80-113
KFK 2784

Velocity Calculated from Drag Disc and Densitometer Measurements

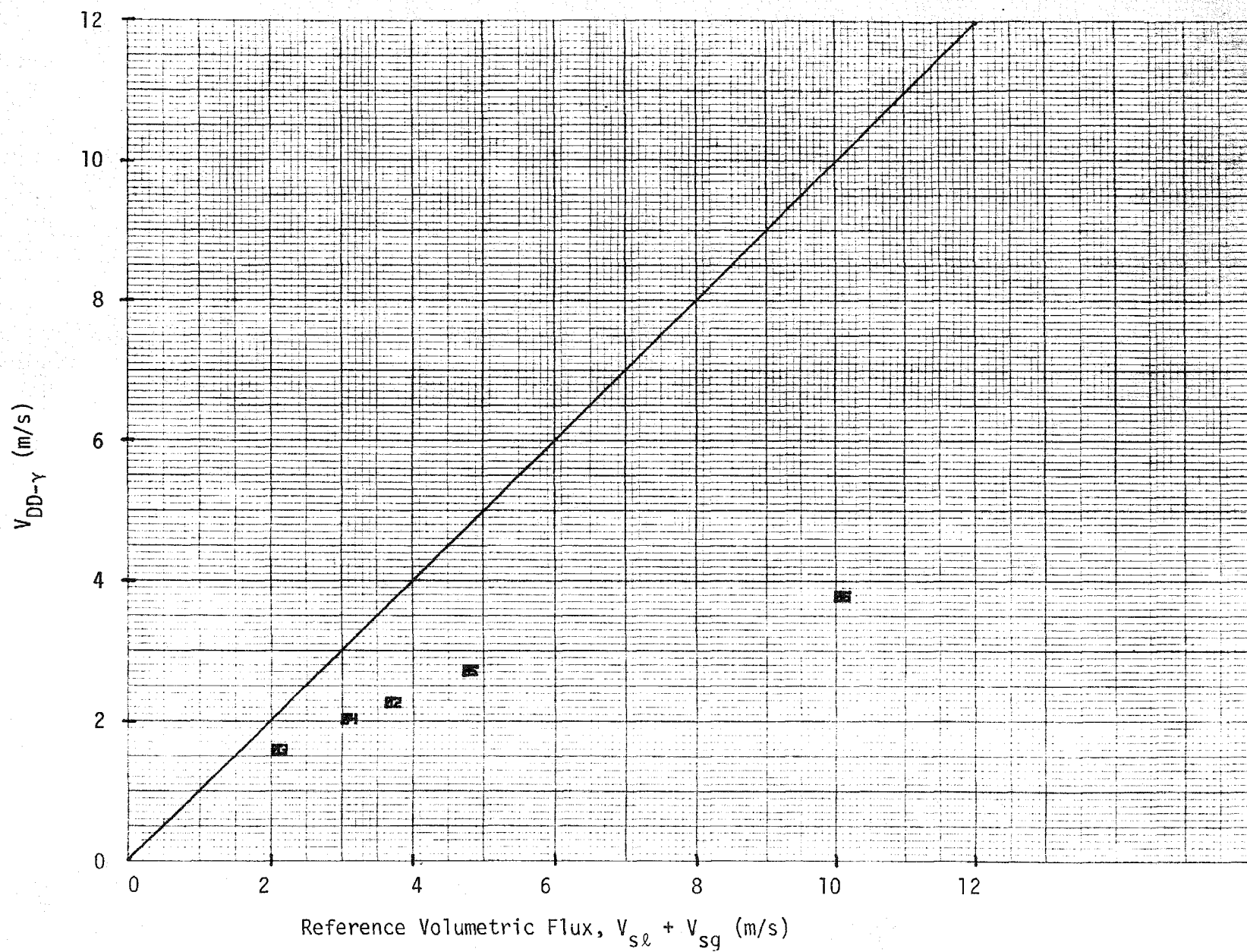


Figure 8.6 The Velocities Calculated from Drag Disc and Densitometer Measurements at Different Reference Volumetric Fluxes

L.R. L0-00-80-113
KFK 2784

Table 8.7
ERROR CALCULATIONS

PHASE II - PLENUM DTT
3 INCH 15 BAR

RUN ID TSN	ALPHA GAMMA	GDOT-GDOT G-T REF (KG/M ² *S)	VT-(VSL+VSG) (M/S)
7102	0.41	-130.83	-1.29
7103	0.05	-48.42	-0.50
7104	0.30	-74.43	-0.94
7105	0.51	-43.71	-1.72
7106	0.67	847.94	-2.89

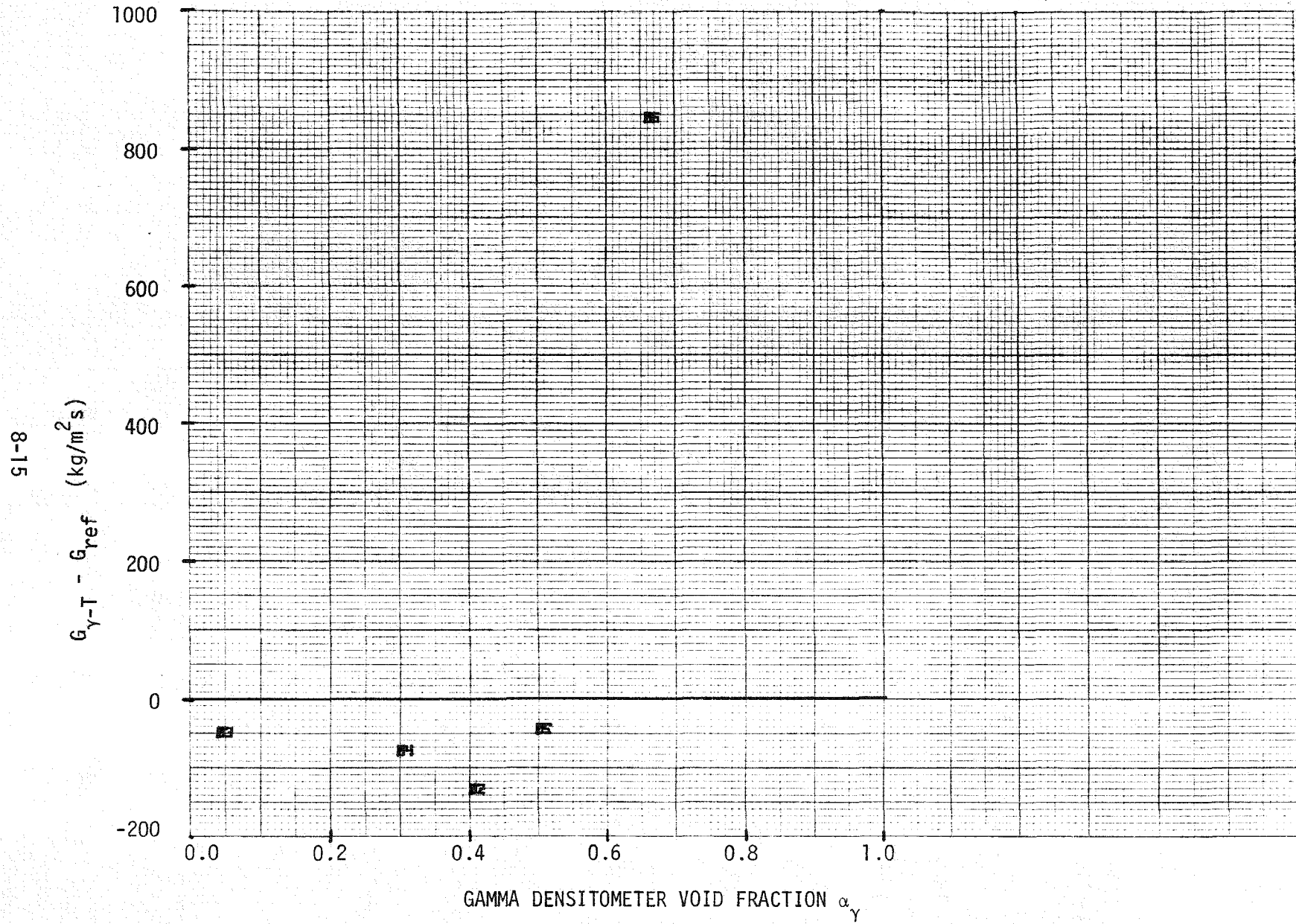


Figure 8.8 Error in Gamma Densitometer - Turbine Mass Flow Calculation

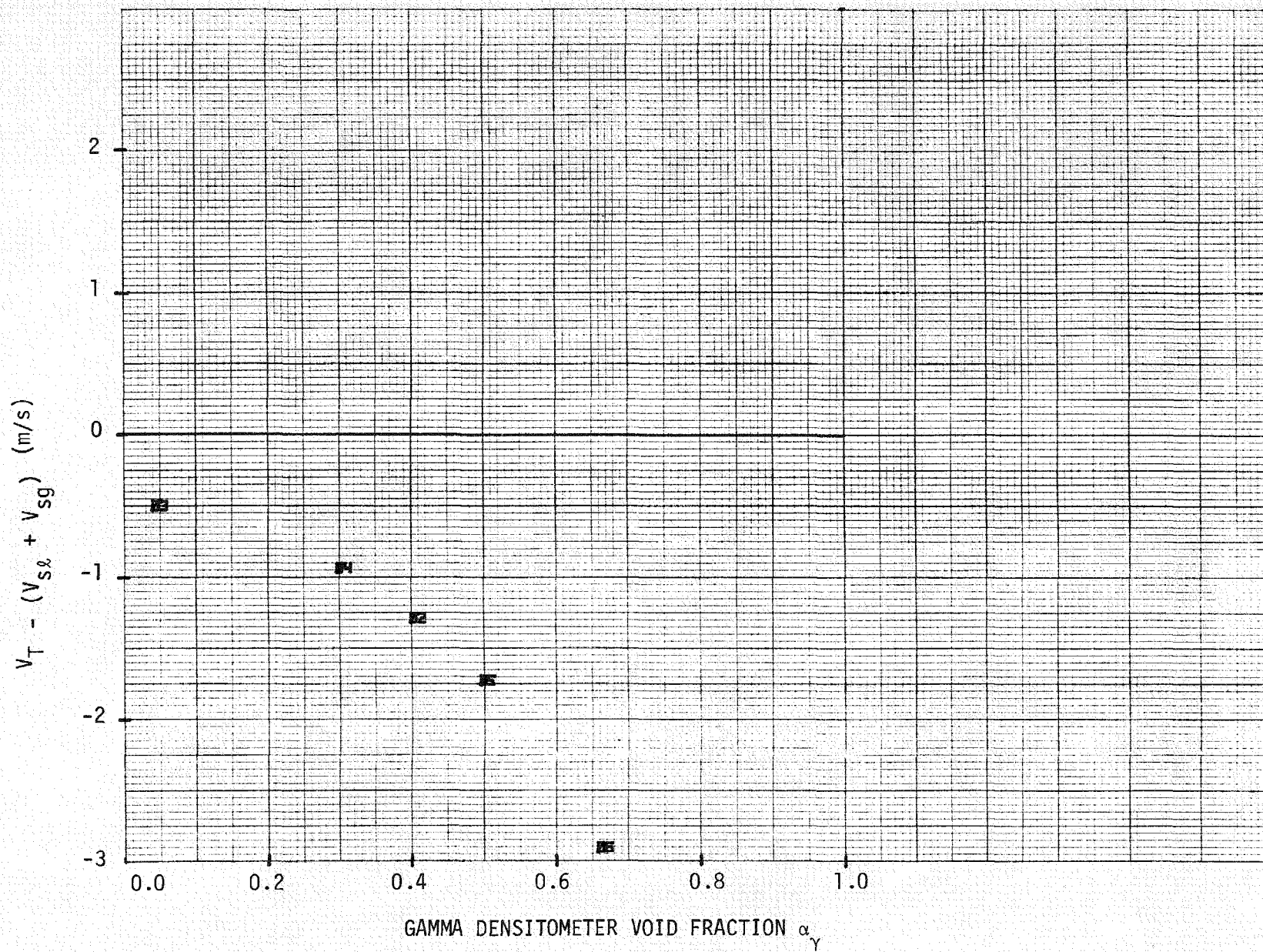


Figure 8.9 Error in Trubine velocity

Table 8.8
SINGLE INSTRUMENT CALCULATIONS

PHASE II - PLENUM DTT
3 INCH 15 BAR

RUN ID	LEN GAMMA	AVG REF	GDOT/(VSL+VSG) REF	DRAG DISK	(GDOT)X(VSL+VSG) REF	(SUM MV/ ALPHA)/AREA
TSN	(KG/M+3)		(KG/M+3)	(KG/M+S+2)	(KG/M+S+2)	(KG/M+S+2)
7102	511.76		369.71	2593	5094.17	3711.88
7103	822.58		651.49	2048	2930.82	2359.31
7104	601.41		443.68	2441	4255.50	3167.79
7105	432.30		286.74	3166	6612.06	4442.07
7106	291.10		123.55	4117	12558.79	5816.59

81-8

Density Measured by Gamma Densitometer (beam length averaged),

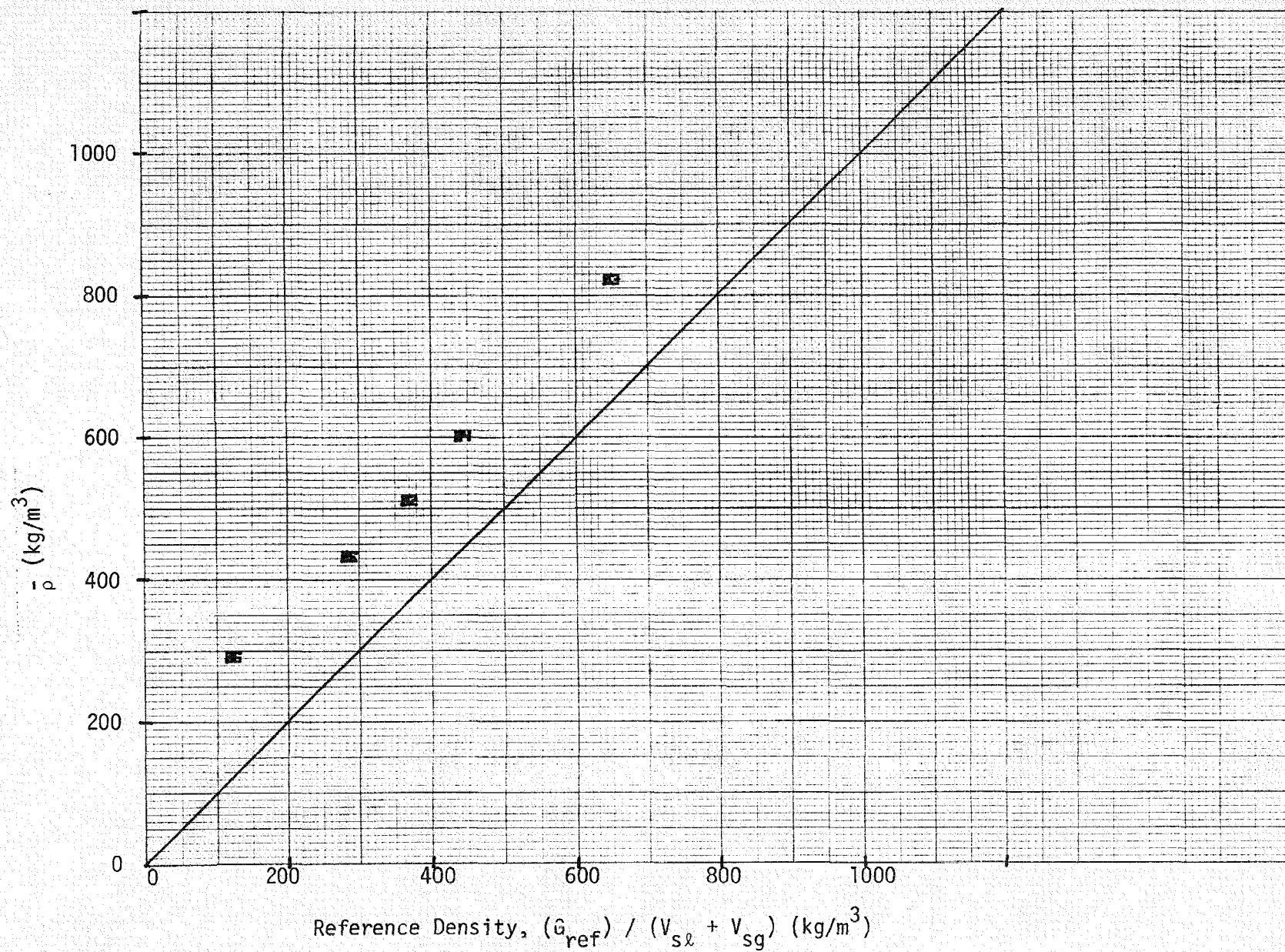


Figure 8.10 Density Comparisons

LTR L0-00-80-113
KFK 2784

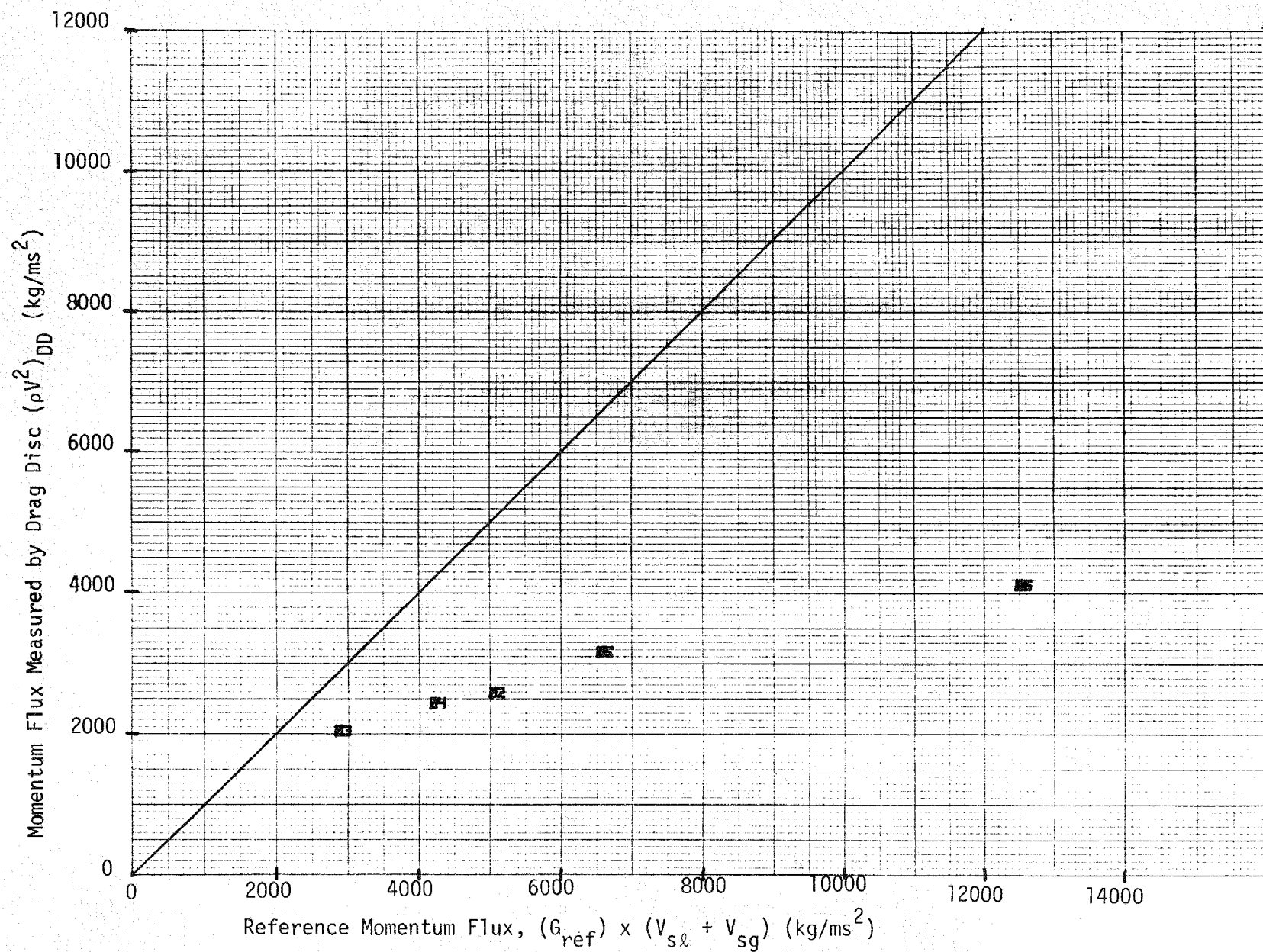


Figure 8.11 Momentum Flux Comparisons

8-20

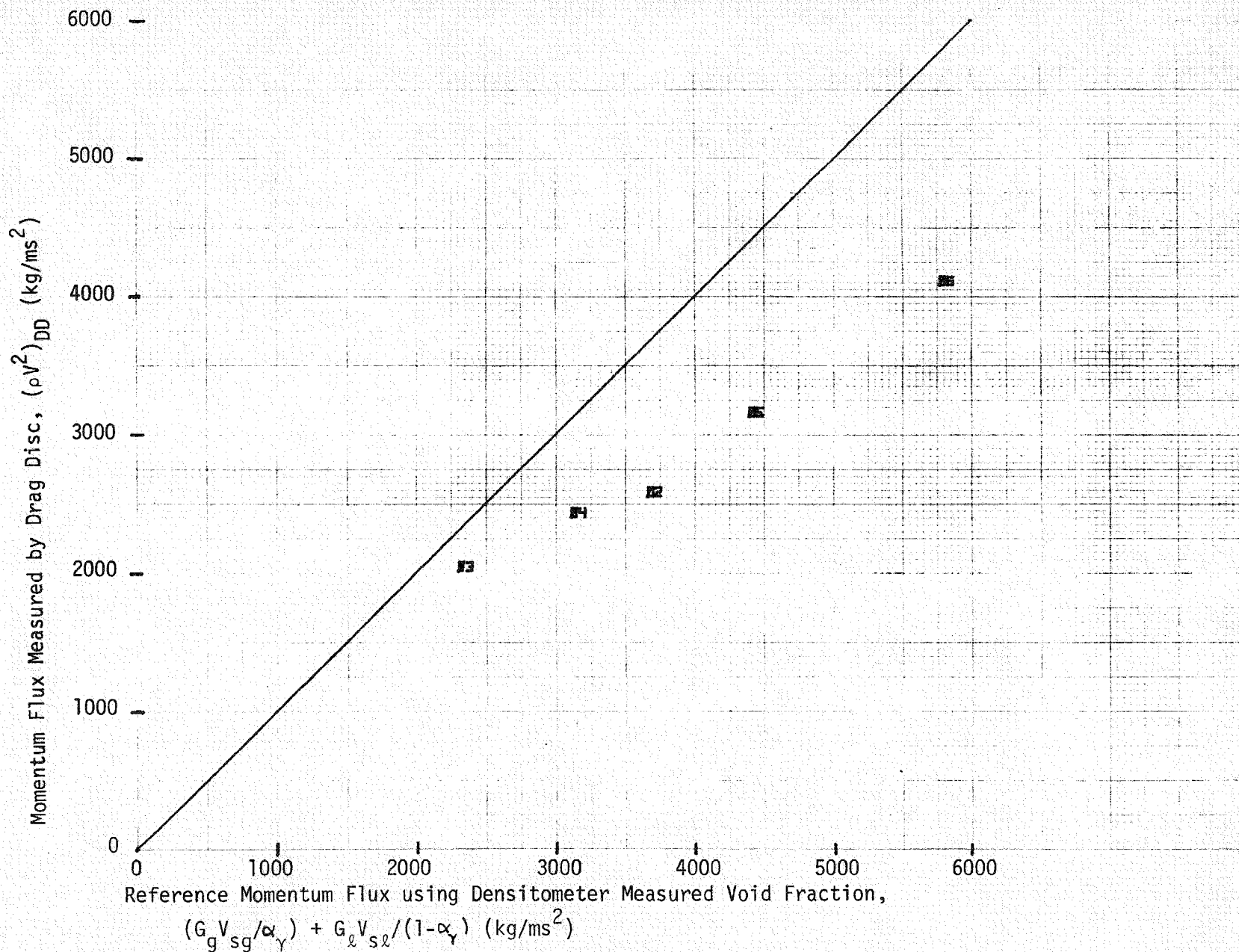


Figure 8.12 Drag Disc Momentum Flux Comparison

LTR LO-00-80-113
 MFR 2/84

9. THREE INCH STEAM-WATER 40 BAR

PLENUM DTT

Table 9.1

PRIMARY ENGINEERING UNIT DATA

FLUID: STEAM - WATER
 PIPE SIZE= 3 INCH SCHEDULE 160
 NOMINAL PRESSURE= 40 BARS

INSIDE DIAMETER= 0.06665 M
 TURB. DIA.= 0.0381 M
 PIPE AREA= 0.0034889 M²

PHASE II - PLENUM DTT

RUN ID	PRESS. (BARS)	TEMP. (DEG C)	FLOW RATES		TURB. VEL (M/S)	DRAG DISK (M ² S ⁻²)	GAMMA DENSITOMETER			RADIOTRACER		
			STEAM SUP-VEL (M/S)	WATER SUP-VEL (M/S)			A BEAM UPPER (M ³)	B BEAM MIDDLE (M ³)	C BEAM LOWER (M ³)	SCAN DENS (M ³)	VELOCITIES STEAM (M/S)	WATER (M/S)
TSN	(BARS)	(DEG C)	(M/S)	(KG/S)	(M/S)	(KG/S)	(M/S)	(KG/)	(KG/)	(KG/)	(KG/)	(AT GAMMA DENS)
7119	40.5	246.0	0.50	0.058	1.579	4.400	2.21	2322	476	549	737	527
7120	41.6	248.1	0.38	0.028	1.649	4.582	2.05	2380	533	616	731	578
7121	40.9	248.8	1.39	0.102	1.634	4.546	3.08	2877	327	422	598	393
7122	38.9	242.7	2.34	0.159	1.569	4.393	3.48	2970	293	382	567	349
7123	37.3	241.3	2.32	0.151	1.043	2.932	5.32	3349	204	302	515	377
7128	42.6	248.5	1.93	0.145	1.060	2.938	5.18	1152	292	369	549	323
7129	38.9	244.2	3.76	0.257	1.026	2.872	4.87	1717	236	303	374	236
7130	35.2	237.3	4.87	0.299	1.032	2.920	5.81	2002	203	277	337	229
7131	44.4	249.9	1.27	0.098	1.154	3.185	2.29	1146	349	441	591	384
7132	41.9	247.8	0.64	0.046	1.090	3.027	1.56	923	461	568	707	490
7133	44.0	251.3	0.25	0.030	1.094	3.008	1.41	1015	528	641	741	606
7134	46.8	252.8	0.13	0.012	1.093	2.994	1.37	977	566	682	755	687
7135	43.3	250.3	0.10	0.021	0.770	2.116	0.96	273	585	706	776	679
7136	41.0	244.9	0.24	0.017	0.762	2.120	0.98	305	551	664	761	640
7137	38.3	244.2	0.75	0.050	0.831	2.329	1.02	366	492	610	751	540
7138	37.9	242.0	1.27	0.084	0.877	2.461	1.49	1074	362	496	637	427

dash indicates error in data
 blank indicates no data

KFK 2784

LTR LO-00-80-113

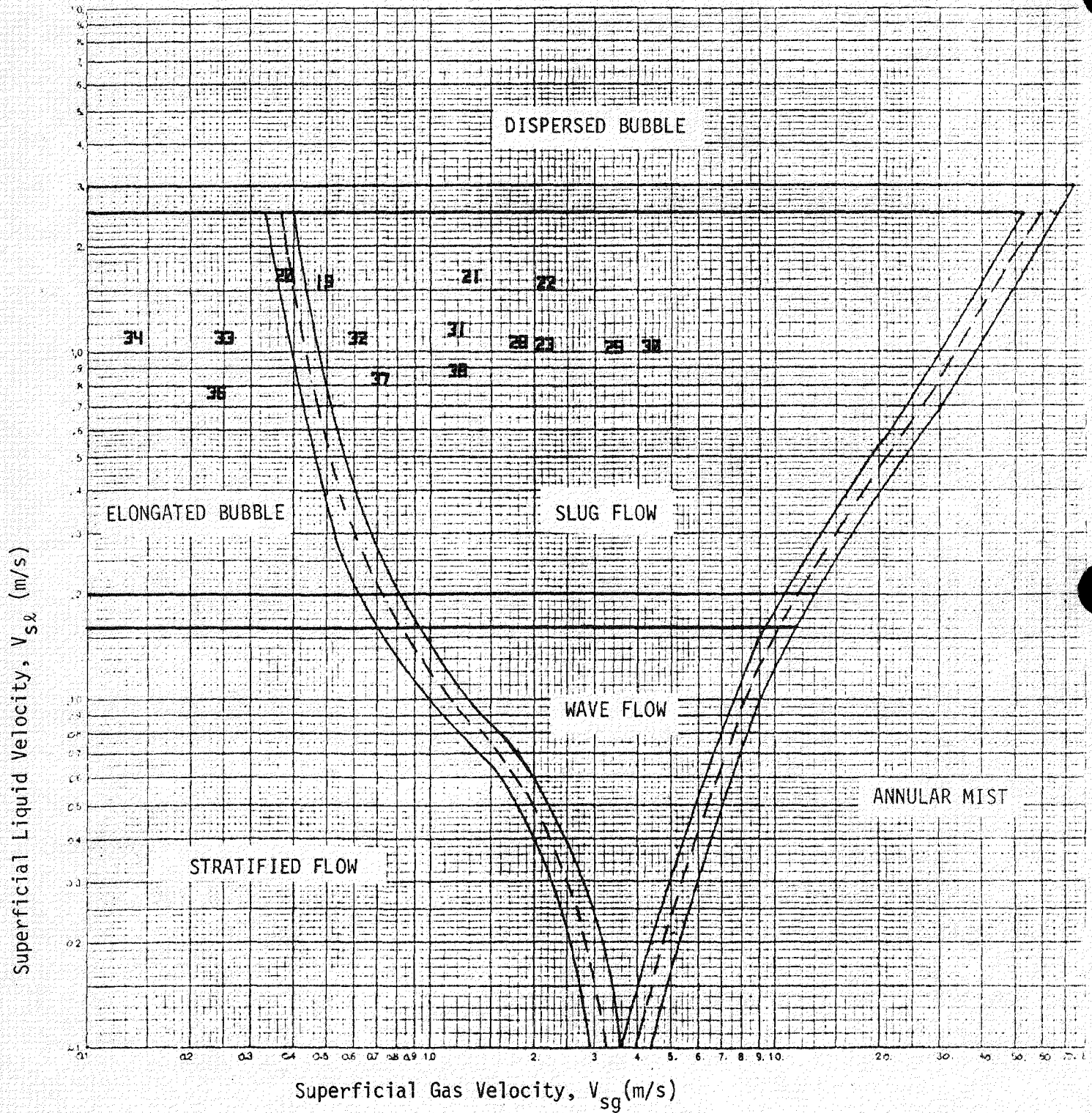


Figure 9.1a Govier and Aziz Flow Regime Map

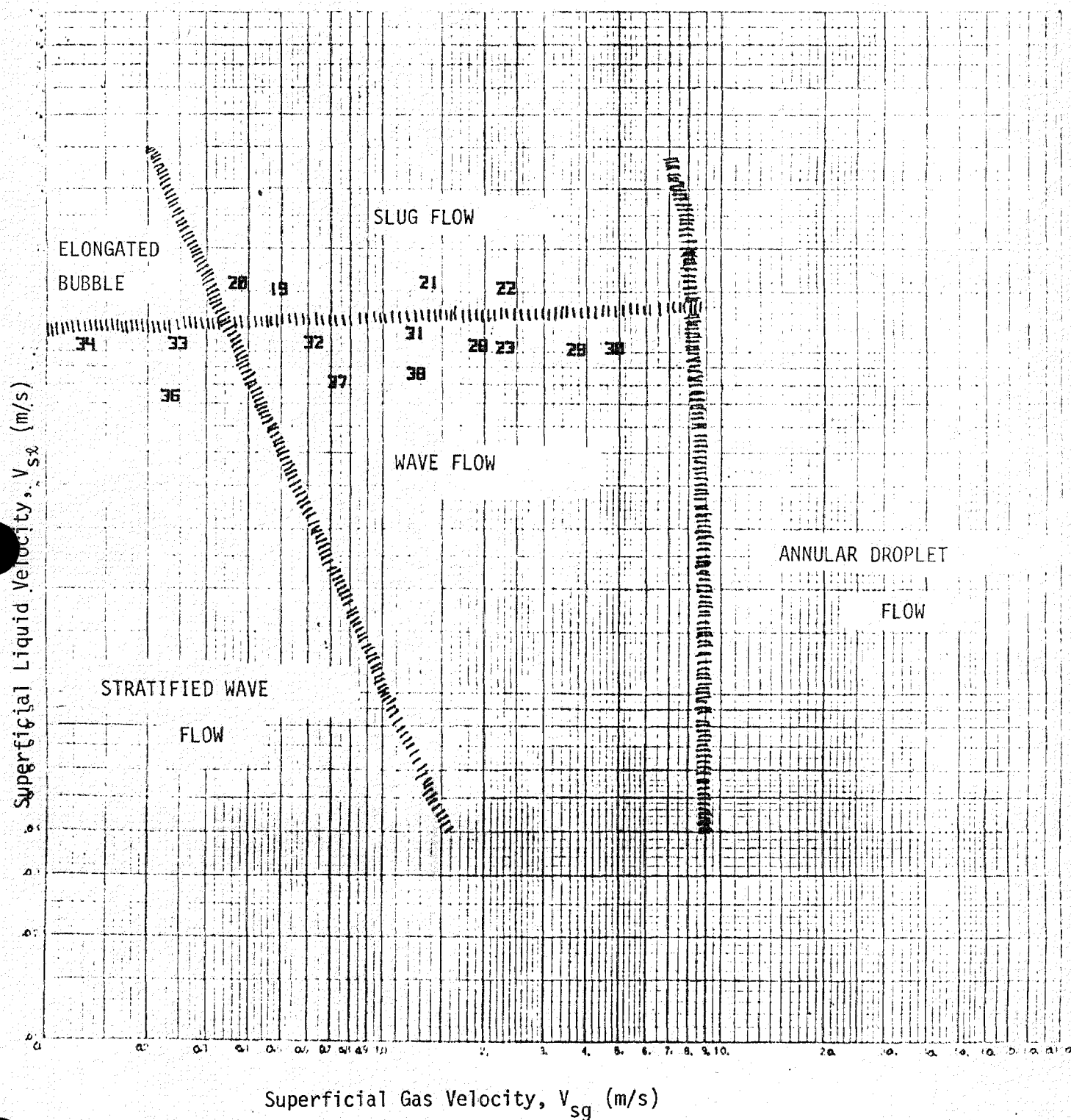


Figure 9.1b Impedance Probe Flow Regime Map

Table 9.2
MASS FLOW RATE COMPARISONS

PHASE II - PLENUM DTT
3 INCH 40 BAR

RUN ID	GDOT REF	GDOT G-T	GDOT G-DD	GDOT T-DD
TSN (KG/M ² *S)	(KG/M ² *S)	(KG/M ² *S)	(KG/M ² *S)	(KG/M ² *S)
7119	1277.767	1265.143	1154.241	1053.061
7120	1321.333	1266.363	1212.821	1161.542
7121	1332.225	1340.796	1119.845	935.306
7122	1304.709	1393.352	1090.954	854.185
7123	883.660	1726.943	1042.949	629.866
7128	883.660	2023.733	670.610	222.222
7129	896.844	1455.066	716.025	352.350
7130	922.640	1553.698	731.753	344.638
7131	940.984	1026.228	717.416	501.532
7132	880.793	888.852	724.382	590.345
7133	870.762	887.001	798.788	719.348
7134	861.590	907.472	804.036	712.391
7135	612.514	653.925	431.850	285.192
7136	612.514	637.649	445.379	311.084
7137	681.877	617.960	471.096	359.136
7138	729.456	724.595	723.426	722.260

Table 9.3
TOTAL VELOCITY COMPARISONS

PHASE II - PLENUM DTT
3 INCH 40 BAR

RUN ID TSN	VSL+VSG (M/S)	TURB. VEL (M/S)	VEL. DD-G (M/S)
7119	2.081	2.205	2.012
7120	2.029	2.049	1.962
7121	3.026	3.076	2.569
7122	3.906	3.477	2.722
7123	3.362	5.317	3.211
7128	2.991	5.184	1.718
7129	4.783	4.873	2.398
7130	5.904	5.809	2.736
7131	2.420	2.285	1.597
7132	1.726	1.564	1.275
7133	1.346	1.411	1.271
7134	1.227	1.372	1.216
7135	0.869	0.958	0.632
7136	1.001	0.980	0.684
7137	1.579	1.018	0.776
7138	2.150	1.487	1.485

Table 9.4
VOID FRACTION COMPARISONS

PHASE II - PLENUM DTT 3 INCH 40 BAR							
DENSITIES (KG/M ³)				VAPOR FRACTIONS			
RUN ID TSN	VERT AVG GAMMA	LEN AVG GAMMA	SCAN DENS	ALPHA GAMMA (LEN)	ALPHA SCAN DENS	ALPHA THERMO	RADIOTRACER VAPOR FRACTION STEAM WATER
7119	569.33	573.76	527.18	0.28	0.34	0.24	
7120	614.68	618.04	577.89	0.22	0.28	0.19	
7121	431.29	435.89	392.88	0.46	0.52	0.46	
7122	396.08	400.73	348.87	0.51	0.58	0.60	
7123	319.52	324.80	277.46	0.61	0.67	0.69	
7128	386.02	390.38	322.75	0.52	0.61	0.65	
7129	296.25	298.60	236.25	0.64	0.72	0.79	
7130	265.19	267.46	228.64	0.68	0.73	0.83	
7131	444.99	449.12	384.48	0.44	0.52	0.52	
7132	564.14	568.32	497.57	0.29	0.38	0.37	
7133	625.02	628.63	606.33	0.21	0.23	0.19	
7134	658.22	661.42	686.97	0.16	0.12	0.11	
7135	679.62	682.88	679.04	0.14	0.14	0.11	
7136	647.22	650.79	647.91	0.18	0.19	0.24	
7137	602.64	607.03	549.11	0.25	0.32	0.47	
7138	482.62	487.29	426.78	0.40	0.48	0.59	

Table 9.5
PHASE VELOCITY COMPARISONS

PHASE II - PLENUM DTT
3 INCH 40 BAR

RUN ID TSN	V GAS G DENS (M/S)	V GAS RADIO (M/S)	V LIQ. G DENS (M/S)	V LIQ. RADIO (M/S)	SLIP G DENS	SLIP RADIO
7119	1.769		2.204		0.803	
7120	1.696		2.125		0.798	
7121	3.015		3.035		0.993	
7122	4.588		3.198		1.435	
7123	3.812		2.663		1.431	
7128	3.721		2.204		1.689	
7129	5.863		2.857		2.052	
7130	7.135		3.254		2.192	
7131	2.876		2.061		1.395	
7132	2.208		1.531		1.442	
7133	1.227		1.377		0.891	
7134	0.855		1.296		0.660	
7135	0.729		0.891		0.818	
7136	1.308		0.932		1.403	
7137	3.053		1.101		2.773	
7138	3.186		1.461		2.181	

Table 9.6
FLOW REGIME COMPARISONS

RUN ID TSN	From Govier & Aziz Flow Regime Map	From Gamma Densitometer		Reference Densitometer	
		Flow Regime	Interface Location(%)*	Flow Regime	Interface Location(%)*
7119	Slug Flow		81.58		
7120	Elongated Bubble		90.34		
7121	Slug Flow		55.19		
7122	Slug Flow		49.07		
7123	Slug Flow		34.72		
7128	Slug Flow		47.32		
7129	Slug Flow		30.43		
7130	Slug Flow		24.93		
7131	Slug Flow		57.81		
7132	Slug Flow		79.94		
7133	Elongated Bubble		91.89		
7134	Elongated Bubble		100.06		
7135	---		103.24		
7136	Elongated Bubble		96.79		
7137	Slug Flow		85.22		
7138	Slug Flow		63.02		

*Pipe Empty: 0.0 cm liquid level is -37.47%
 Pipe Full: 6.665 cm liquid level is 137.47%
 Bottom of DTT Housing: 1.4275 cm liquid level is 0.0%
 Top of DTT Housing: 5.2375 cm liquid level is 100.0%

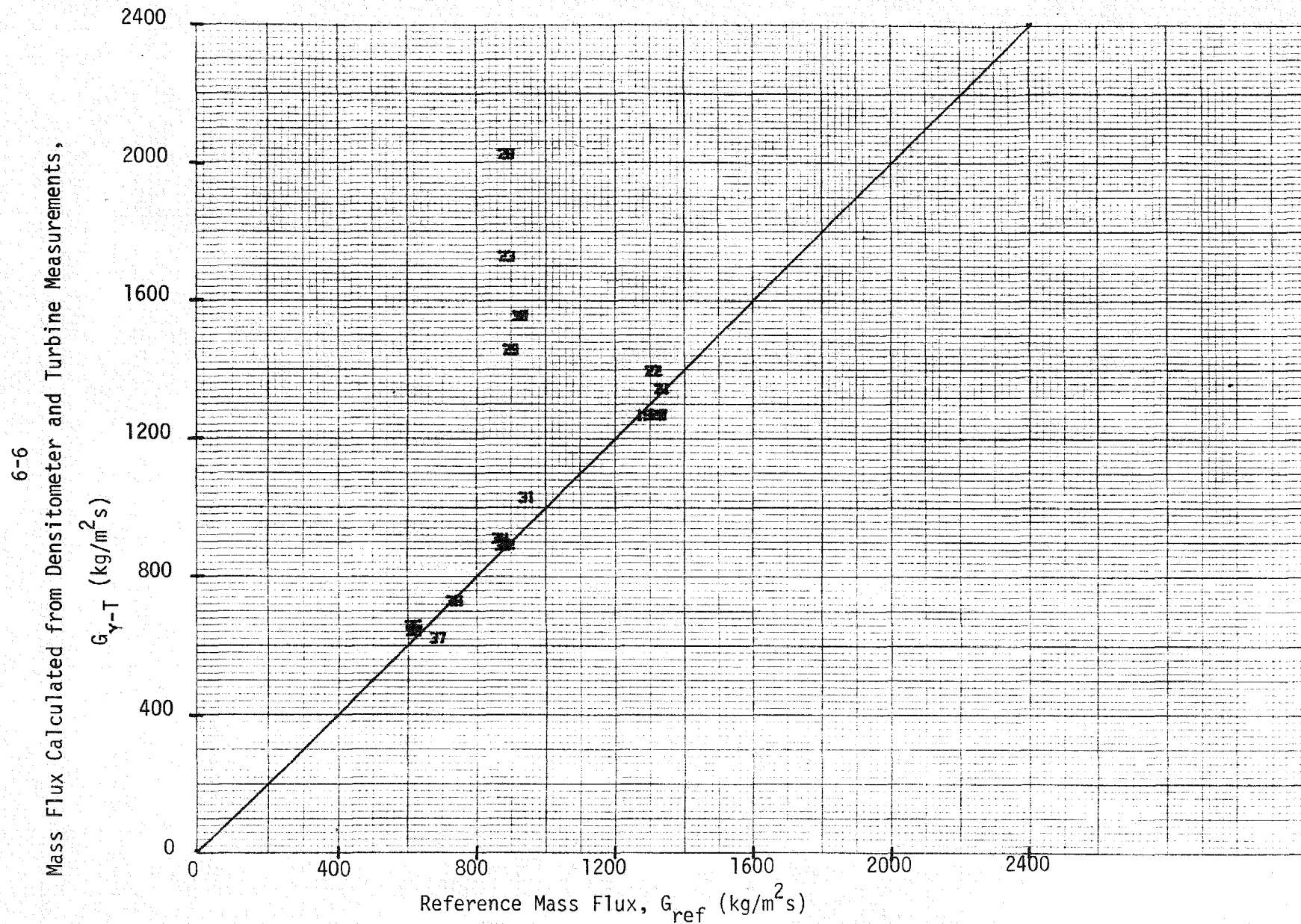


Figure 9.2 Mass Fluxes Calculated from Gamma Densitometer and Turbine Measurements at Different Reference Values

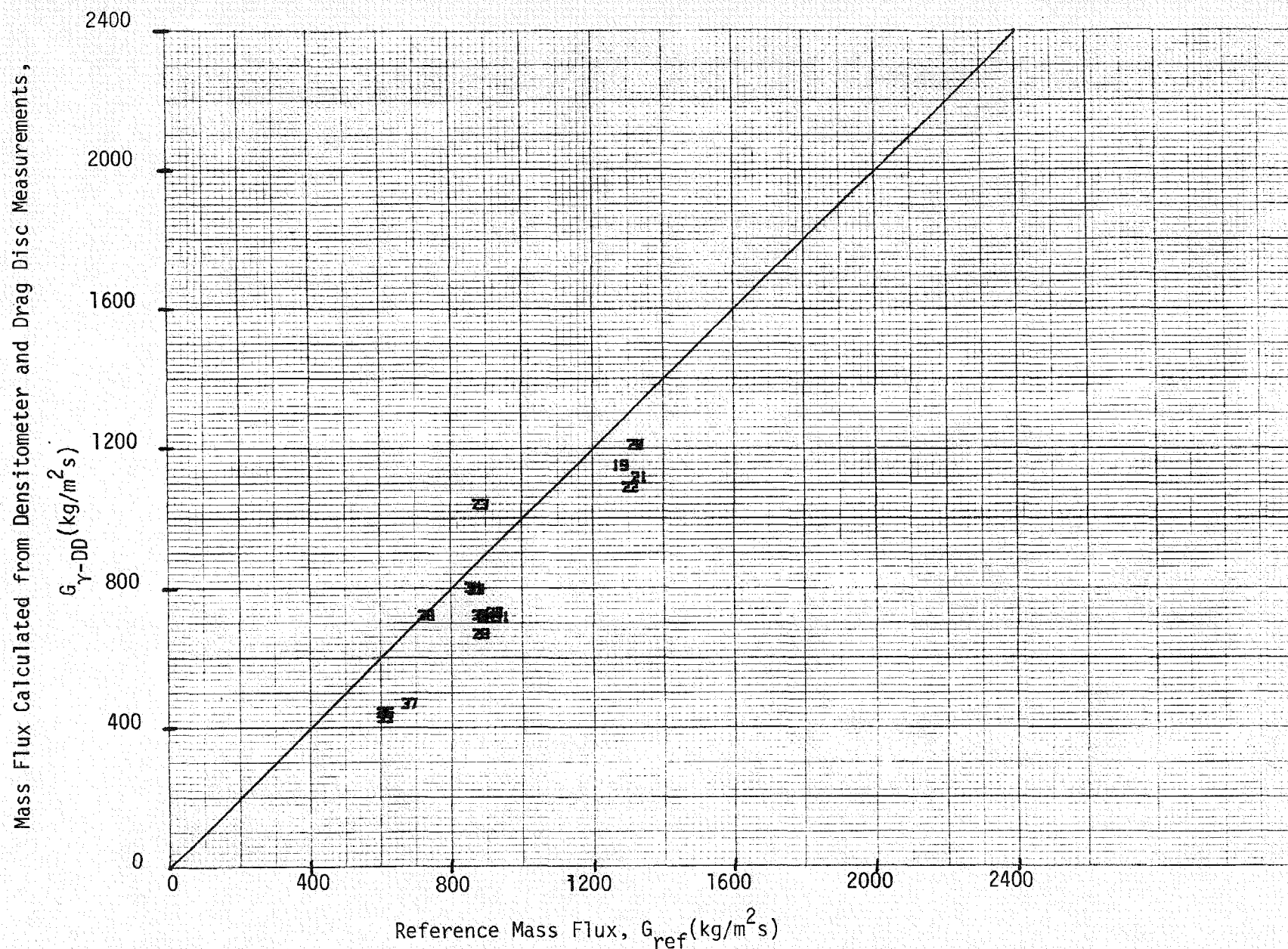


Figure 9.3 Mass Fluxes Calculated from Gamma Densitometer and Drag Disc Measurements at Different Reference Values

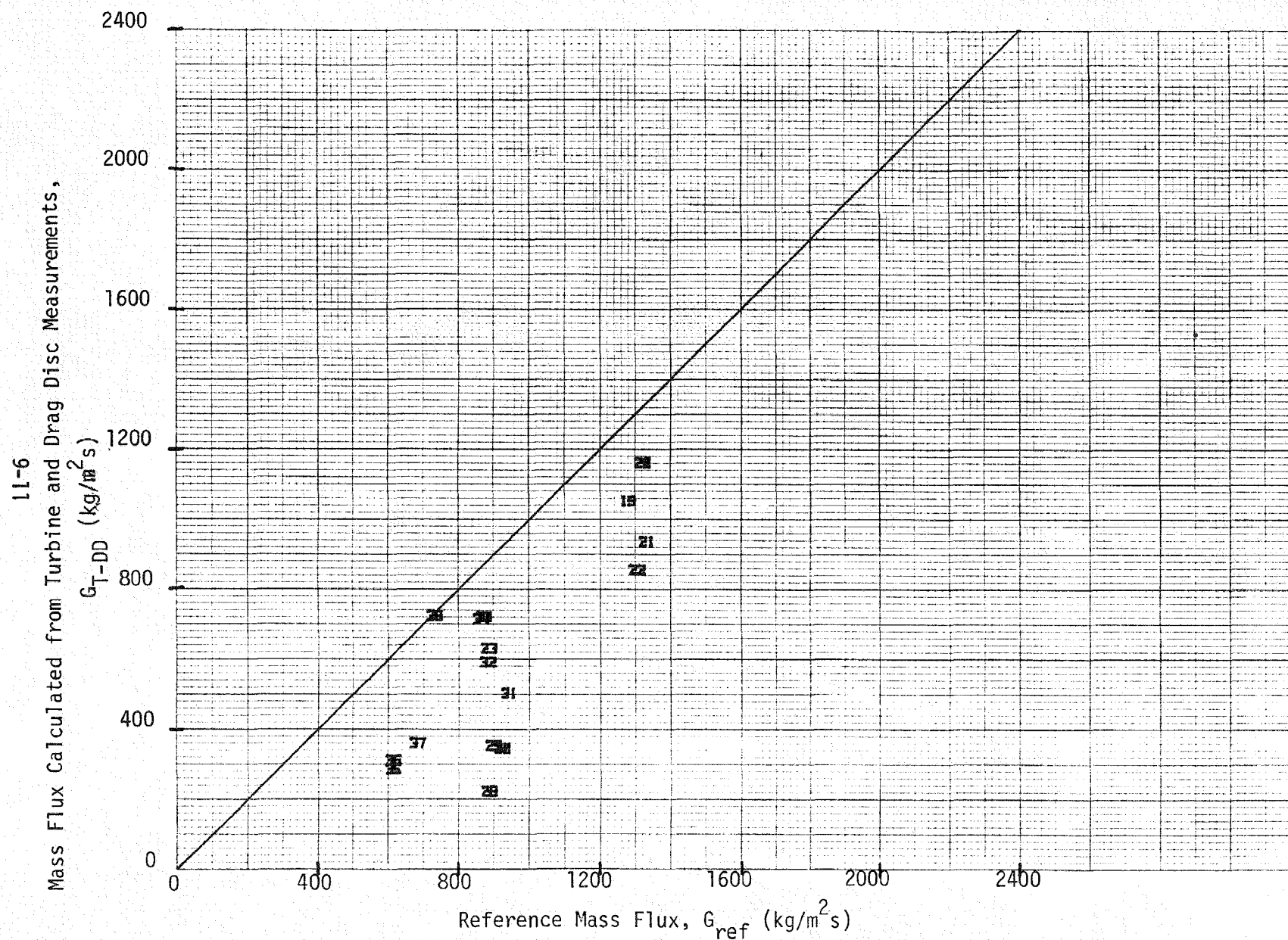


Figure 9.4 Mass Fluxes Calculated from Turbine and Drag Disc Measurements at Different Reference Values

9-12

Velocity Measured by Turbine, V_T (m/s)

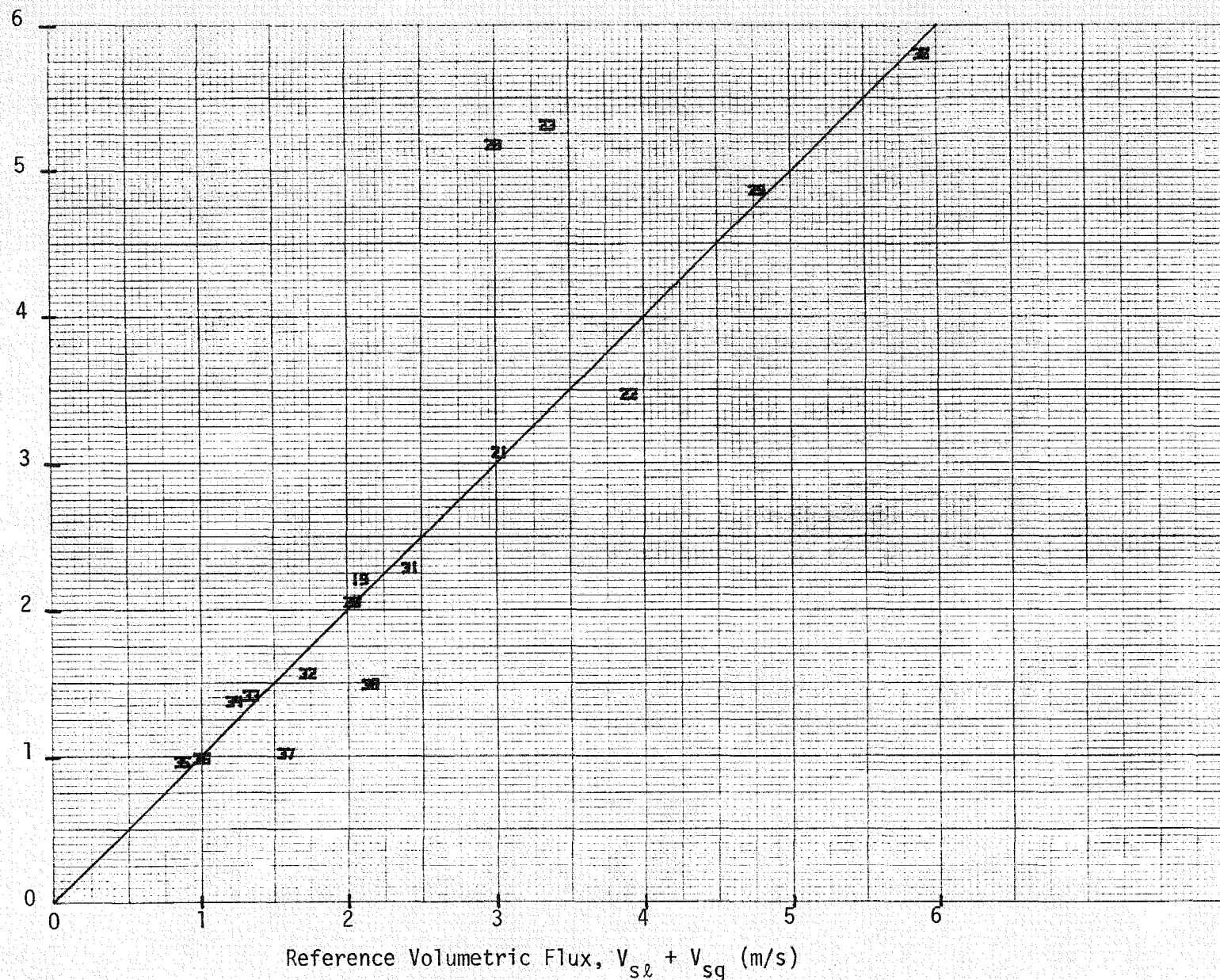


Figure 9.5 The Velocities Measured by Turbine at Various Volumetric Fluxes

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ϵ_{L-6}
 Velocity Calculated from Drag Disc and Densitometer Measurements
 $V_{DD-\gamma}$ (m/s)

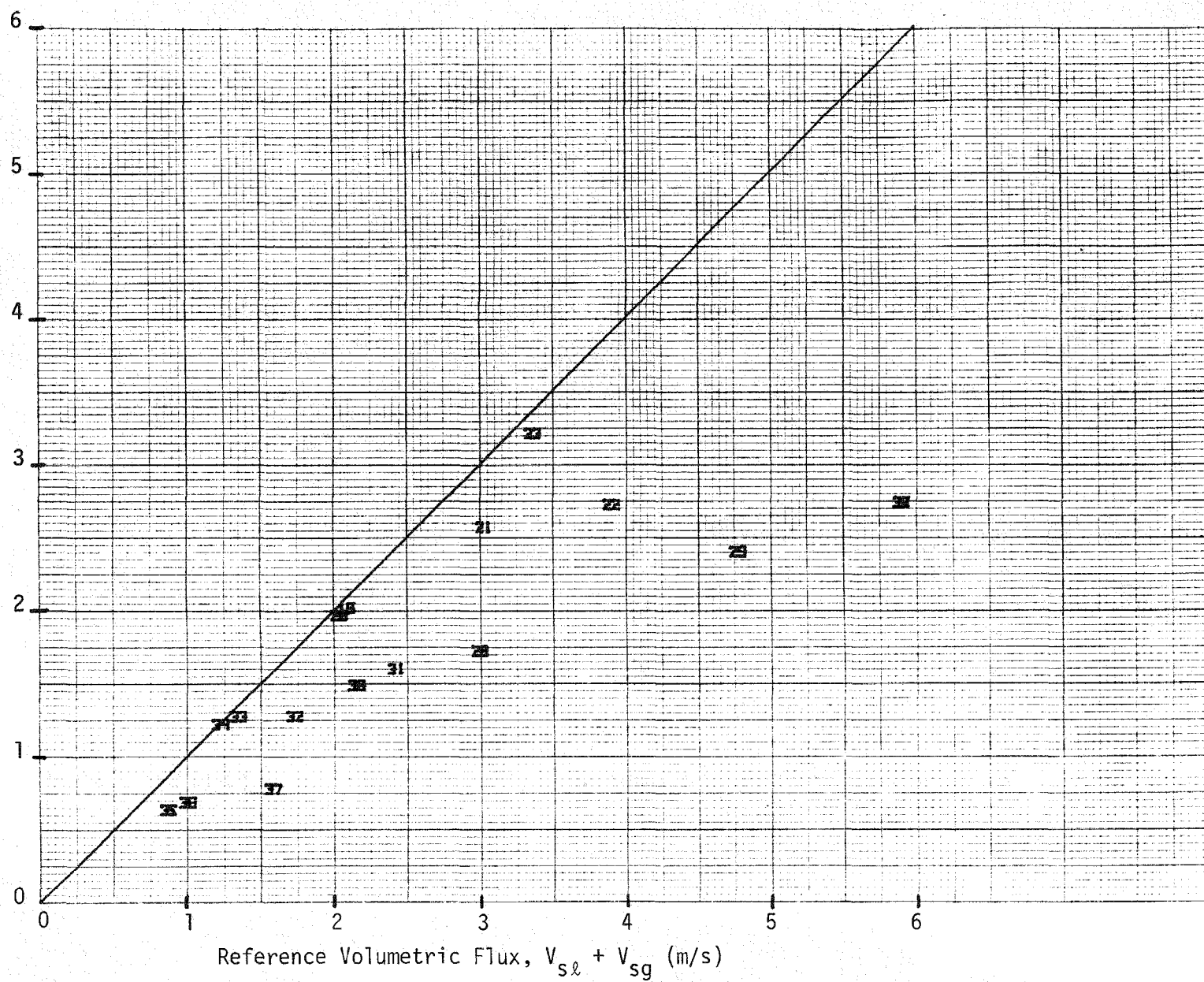


Figure 9.6 The Velocities Calculated from Drag Disc and Densitometer Measurements at Different Reference Volumetric Fluxes

Table 9.7
ERROR CALCULATIONS

PHASE II - PLENUM DTT
3 INCH 40 BAR

RUN ID TSN	ALPHA GAMMA	GDOT-GDOT G-T REF (KG/M ² *S)	VT-(VSL+VSG) (M/S)
7119	0.28	-12.62	0.12
7120	0.22	-54.97	0.02
7121	0.46	8.57	0.05
7122	0.51	88.64	-0.43
7123	0.61	843.28	1.96
7128	0.52	1140.07	2.19
7129	0.64	558.22	0.09
7130	0.68	631.06	-0.10
7131	0.44	85.24	-0.14
7132	0.29	8.06	-0.16
7133	0.21	16.24	0.07
7134	0.16	45.88	0.15
7135	0.14	41.41	0.09
7136	0.18	25.13	-0.02
7137	0.25	-63.92	-0.56
7138	0.40	-4.86	-0.66

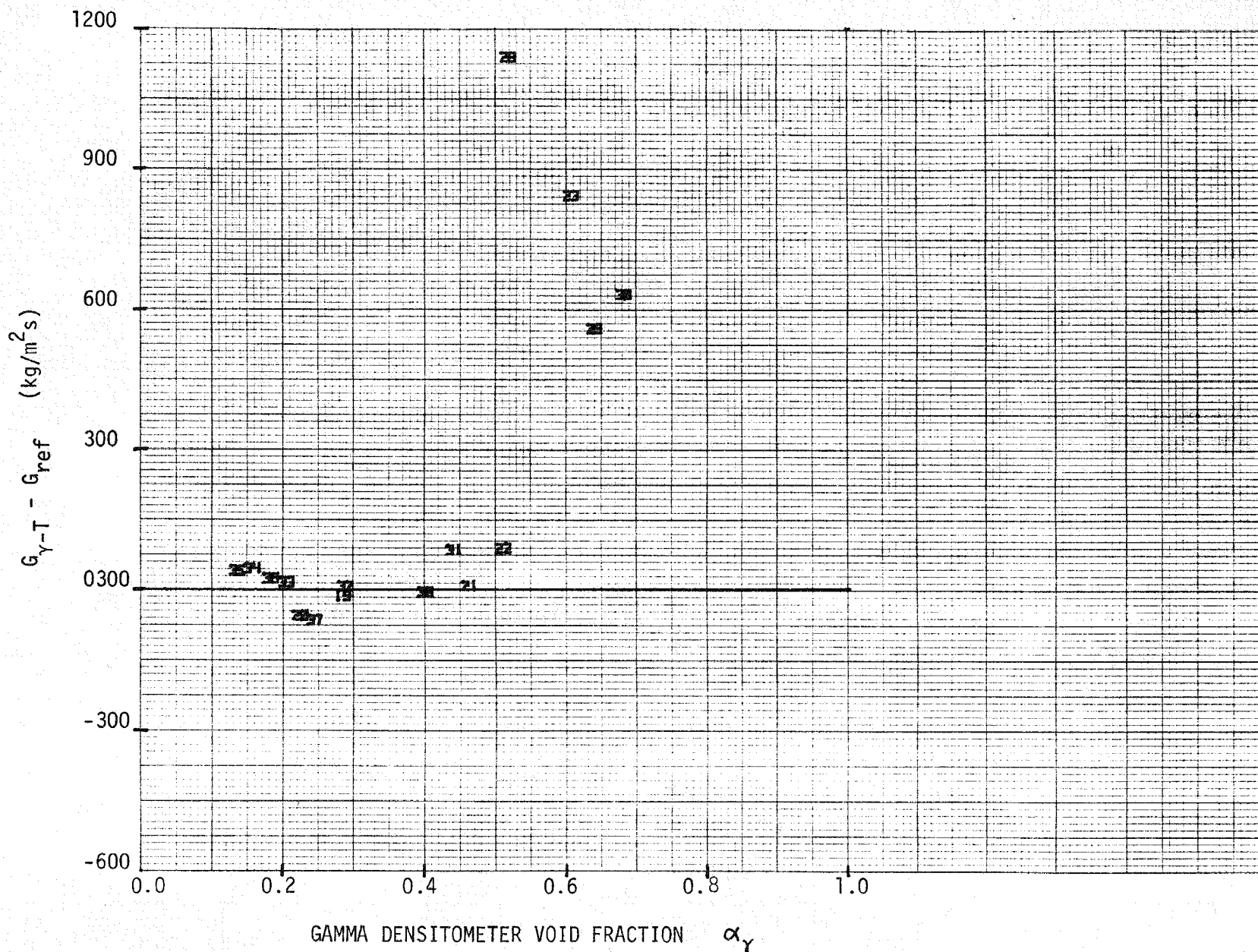


Figure 9.8 Error in Gamma Densitometer- Turbine Mass Flow Calculation

9-16
 $V_T - (V_{sl} + V_{sg})$ (m/s)

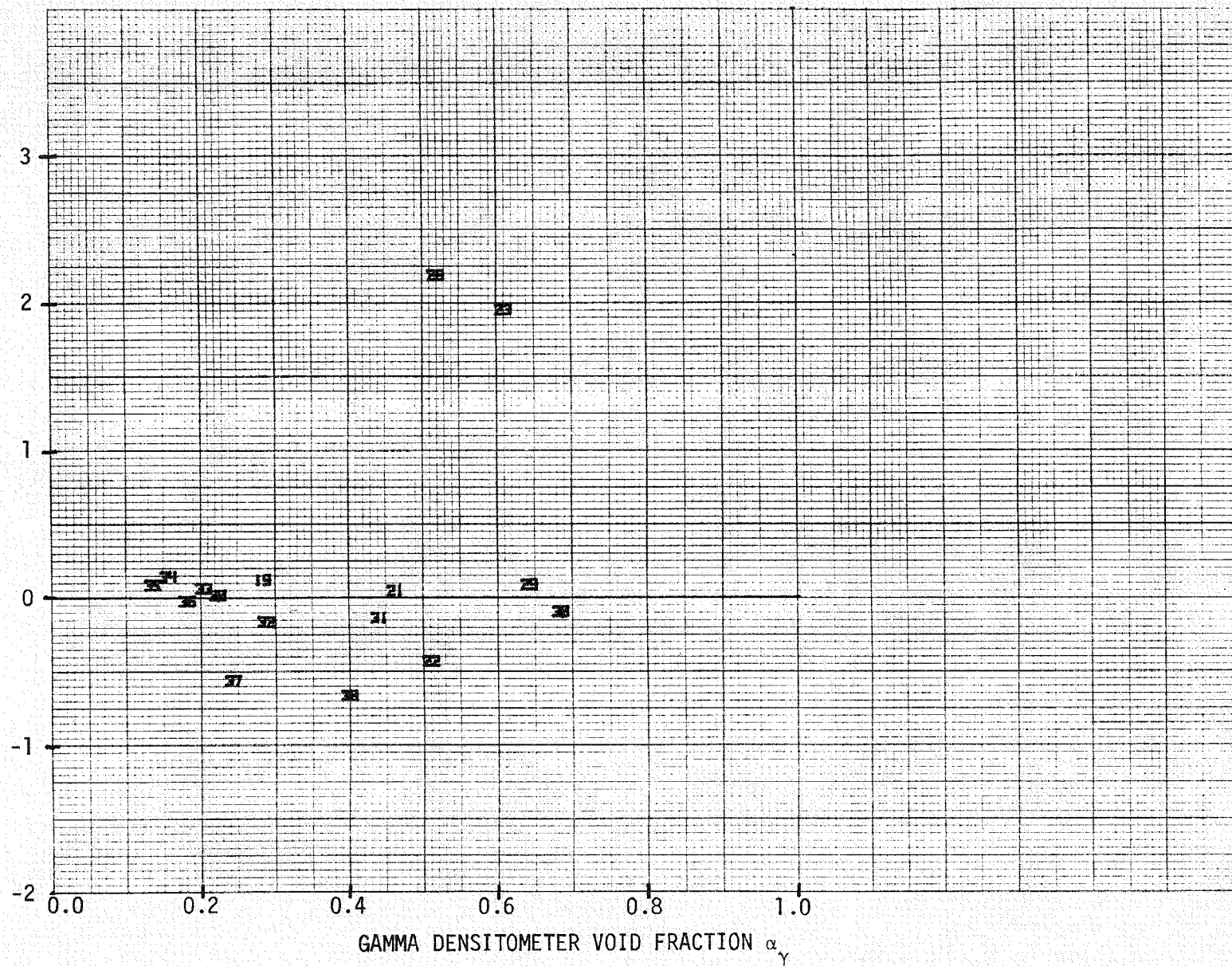


Figure 9.9 Error in Turbine Velocity

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XFK 2781

Table 9.8
SINGLE INSTRUMENT CALCULATIONS

PHASE II - PLENUM DTT 3 INCH 40 BAR						
RUN ID TSN	LEN GAMMA (KG/M ³)	AVG REF (KG/M ³)	GDOT/(VSL+VSG) REF (KG/M ³)	DRAG DISK (KG/M ³ S ²)	(GDOT)X(VSL+VSG) REF (KG/M ³ S ²)	(SUM MV/ ALPHA)/AREA (KG/M ³ S ²)
7119	573.76		614.02	2322	2659.03	2809.51
7120	618.04		651.22	2380	2680.99	2804.64
7121	435.89		440.26	2877	4031.31	4043.17
7122	400.73		334.03	2970	5096.19	4235.97
7123	324.80		262.84	3349	2970.86	2403.30
7128	390.38		295.44	1152	2643.03	2010.18
7129	298.60		187.51	1717	4289.61	2783.10
7130	267.46		156.27	2002	5447.27	3335.47
7131	449.12		388.84	1146	2277.18	1962.77
7132	568.32		510.31	923	1520.25	1357.50
7133	628.63		646.93	1015	1172.05	1197.47
7134	661.42		702.19	977	1057.17	1115.10
7135	682.88		704.85	273	532.27	544.80
7136	650.79		611.90	305	613.13	572.94
7137	607.03		431.84	366	1076.68	778.51
7138	487.29		339.28	1074	1568.33	1107.05

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Density Measured by Gamma Densitometer (beam length averaged),

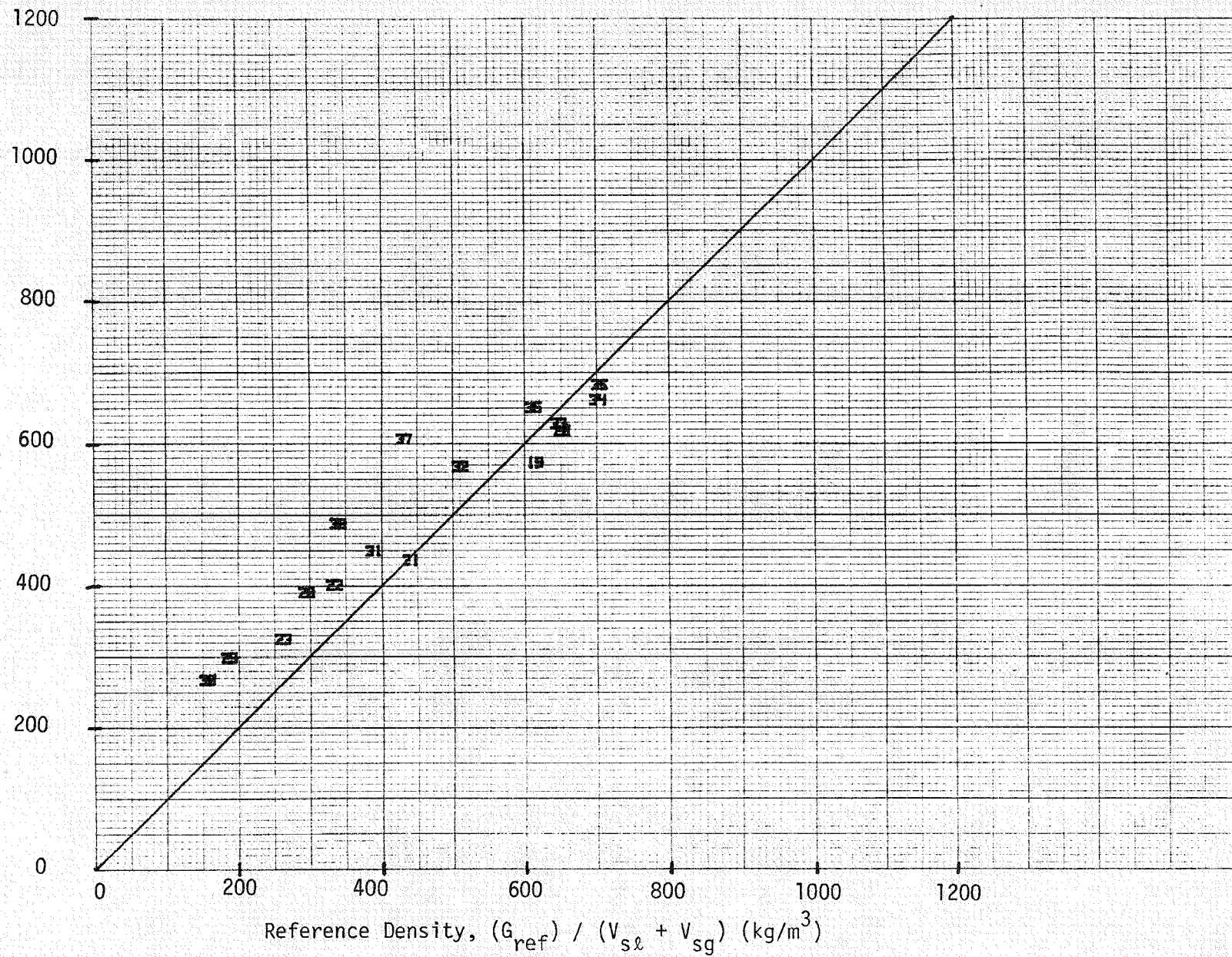
 $\bar{\rho}$ (kg/m³)

Figure 9.10 Density Comparisons

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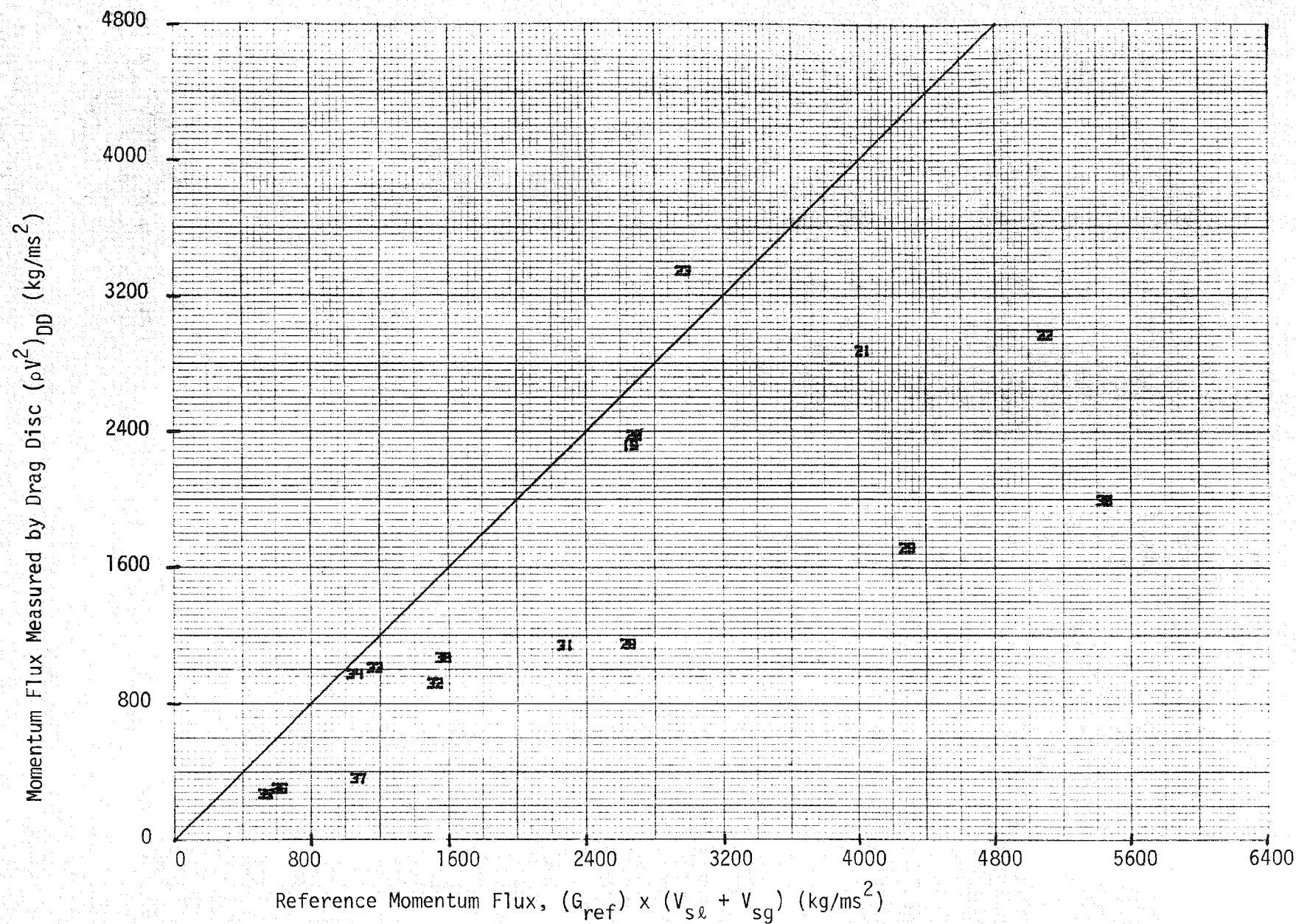
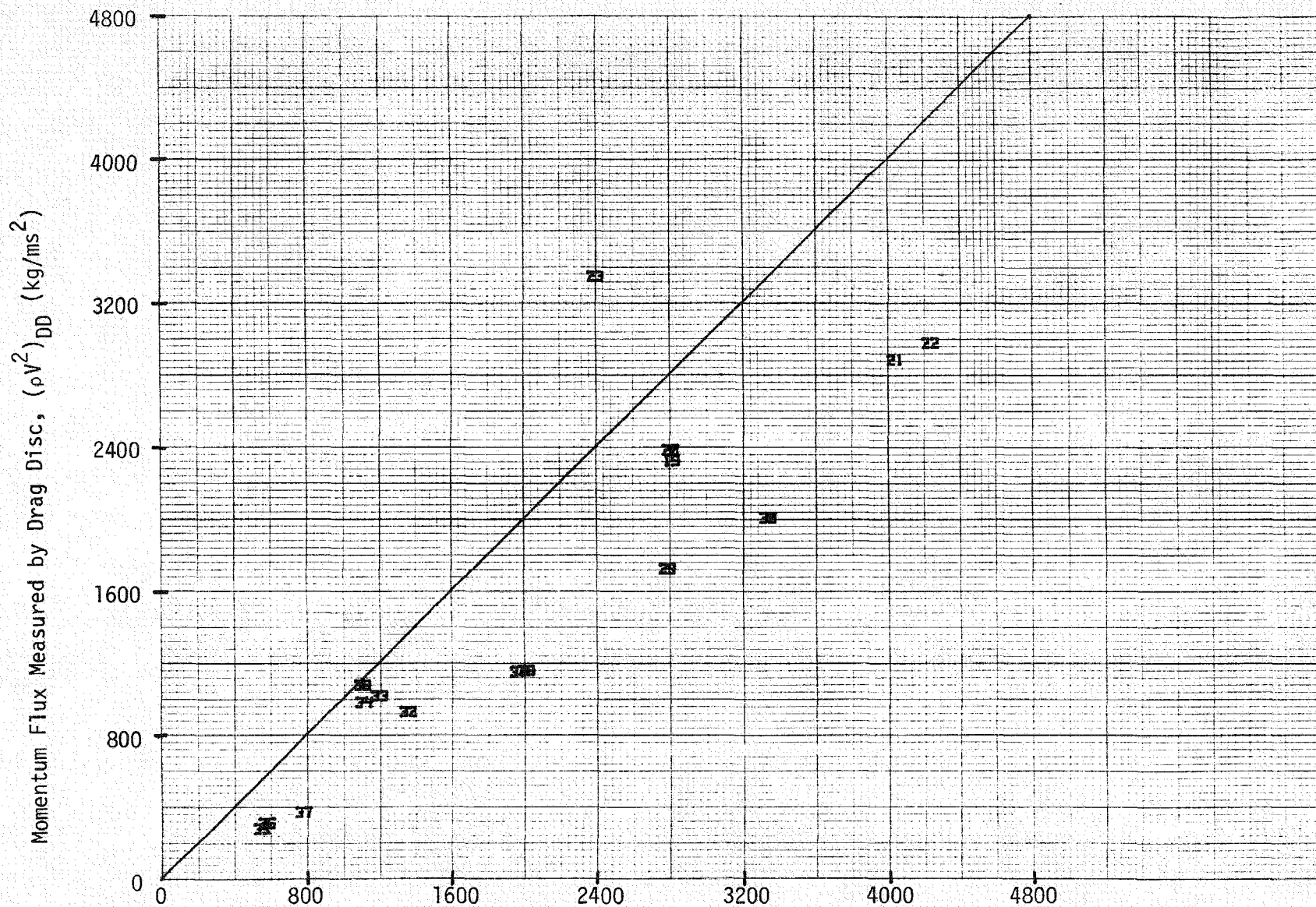


Figure 9.11 Momentum Flux Comparisons



Reference Momentum Flux using Densitometer Measured Void Fraction,
 $(G_g V_{sg}/\alpha_Y) + G_g V_{sl}/(1-\alpha_Y)$ (kg/ms²)

Figure 9.12 Drag Disc Momentum Flux Comparison

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APPENDIX 1

OPERATION LOG AND SETUP SHEETS

INSTRUMENTATION LOG SHEET

Setup Ref. No. 100

SENSOR			CHANNEL				BL	HP Coefficients			
ID	Make	SN	BL	TR	SC	HP	Gain	a ₀	a ₁	a ₂	a ₃
			1	1							
P3	CEC 1000	2611	2	2	1	S7	1000	12.78	63.008		
P7	CEC 1000	2613	3	3	2	S5	1000	12.70	59.456		
D9	BLH 20"	39192	4	4	3	S8	1000	-9.7770 ⁻⁶	6.80x10 ⁻⁴		
			5								
			6								
			7	5							
R4	Loft 3x		8	6	7		1	124.82	10.01	0	
R5	Loft 3x		9	7	8		1	107.09	10.01	0	
R6	Loft 3x		10	8	9		1	180.71	10.01	0	
Q4	EXP-M-1		11	9	10		2				
RS	EXP-M-1		12	10	11		2				
			13	11	12						
T10	EXP-M-1		14	12	4	T ₁₃	1000	150.4	45.28	-1.573	.00288
T4			15	13	5	T ₁₄	1000	150.4	45.28	-1.573	.00288
IRIGA			-	14	-	-					

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OPERATION LOG SHEET

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Date

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END			RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7000 C	100	4/15:14.20 15:20.20 15:24.20	15:22.10 15:22.10					0 25 50 75 100
7000	00	16:18.40	16:20.20					I 10 Reversed
7001	40	16:26.20	16:27.10					
7002		16:30.45	16:31.30					
7003		16:34.35	16:35.20					
7004	125	16:37.30	16:40.30					Don't see target
7005		16:45.00	16:46.00					

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Date

7/16/77

TSN	SETUP REF. NO.	IRIG.START	IRIG.END			RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7006		46.40	47.10					Dray line Type 101
7007								
7008	252	16:23.30	5:46.5					
AI-3 7009		16:53.00	16:58.15					Types running 30 sec before run began - good data D.7 Reg.
7010		17:00.50	17:01.15					no 30 sec leader on front of run
7011		17:04.30	17:06.10					Flow started to drop off attend
7012		17:08.50	17:09.30					

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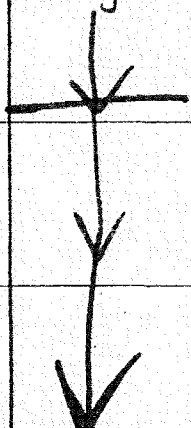
OPERATION LOG SHEET

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Date

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END			RADIO TRACER DATA	IMP. PROBE DATA		COMMENTS
7013	100	41 17:11.55	17:12.40	-	-	-	-	-	Drag Disc tapped out
7014		17:14.30	17:15.20	-	-	-	-	-	
7015 AI-4		17:17.20	17:18.20	-	-	-	-	-	
7016		17:21.15	17:22.00	-	-	-	-	-	Drag Disc Clipping End
7017		17:24.25	17:25.25	-	-	-	-	-	Drag Disc OK
7018		17:27.40	17:32.55	-	-	-	-	-	Same point as 70 Densitometer on a 17:28.15
7019		17:36.10	17:37.40						

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5 minute max. ran dens. up bmo

LTR LO-00-80-113

Comments

KFK 2784

TAPE SPEED: 7 1/2 IP

SENSOR			CHANNEL				BL	HP Coefficients			
ID	Make	SN	BL	TR	SC	HP	Gain	a_0	a_1	a_2	a_3
			1	1							
P3	CEC 1000	2611	2	2	1		500	12.78	63.008		
P7	CEC 1000	2613	3	3	2		500	12.70	59.656		
D9	BLN 30°	39192	4	4	3		1000	-9.71×10^{-6}	6.80×10^{-4}		
			5								
			6								
			7	5							
R4	LORE #3B	-	8	6	7		1	124.82	10.01	0	
R5	"	-	9	7	8		1	107.02	10.01	0	
R6	"	-	10	8	9		1	180.71	10.01	0	
Q4		EXP-M-1	11	9	12		2				
F5		"	12	10	11		2				
			13	11	12						
T10		"	14	12	4		1000	150.4	45.28	-1573	.00288
T4			15	13	5		1000	150.4	45.28	-1573	.00288
IRIGA			-	14	-	-					

INSTRUMENTATION LOG SHEET

Setup Ref. No. 102

SENSOR			CHANNEL				BL	HP Coefficients				Comments
ID	Make	SN	BL	TR	SC	HP	Gain	a_0	a_1	a_2	a_3	
			1	1								
P3	CEC 1000	2611	2	2	1		500	12.78	126.016			
P7	CEC 1000	2613	3	3	2		500	12.70	119.312			
D9	314 30	39192	4	4	3		1000	-9.7×10^{-6}	6.80×10^{-4}			
			5									
			6									
			7	5								
R4	LOFT #38	-	8	6	7		1	124.82	10.01	0		
R5	"	-	9	7	8		1	107.09	10.01	0		
R6	"	-	10	8	9		1	180.71	10.01	0		
Q4		EXP-M-1	11	9	12		2					
F5		"	12	10	11		2					
					12							
T10		"	13	11	4		1000	150.4	45.28	-1573	.00288	
T4			15	13	5		1000	150.4	45.28	-1573	.00288	
TRIGA			-	14	-	-						

Setup Ref. No. 103

SENSOR			CHANNEL				BL	HP Coefficients				Comments
ID	Make	SN	BL	TR	SC	HP	Gain	a ₀	a ₁	a ₂	a ₃	
			1	1								LTR L0-00-80-113 KFK 2784 TAPE SPEED : 7 1/2 IPS.
P3	CEC 1000	2611	2	2	1		500	12.78	126.016			
P7	CEC 1000	2613	3	3	2		500	12.70	119.312			
D9	SLM 20	39192	4	4	3		1000	-9.71x10 ⁻⁶	6.86x10 ⁻⁴			
			5									
			6									
			7	5								
R4	LOFT #38	-	8	6	7		1	124.82	10.01	0		
R5	"	-	9	7	8		1	107.09	10.01	0		
R6	"	-	10	8	9		1	180.71	10.01	0		
Q4			11	9	12		2					SPARK DTT. Not Modular
F5		"	12	10	11		2					
T10		"	13	11	4		1000	150.4	45.28	-.1573	.00288	
T4			15	13	5		1000	150.4	45.28	-.1573	.00258	
T21GA			-	14	-	-						

INSTRUMENTATION LOG SHEET

NW 50 - water

NW 32 - water

Setup Ref. No. 40

4 Bar

Semiscale STEAM-WATER

LTR LO-00-80-113

IRIG-A

SENSOR			CHANNEL				BL	HP Coefficients				Comments
ID	Make	SN	BL	TR	SC	HP	Gain	a ₀	a ₁	a ₂	a ₃	
P1	H	53 TM11	1	1-1	1	1	2	10.43	299.06			STEAM - NW 65
P2	B	53 TM9	1	1-1	1	1	2	10.43	299.06			STEAM - NW 100
P3	CEC	100- 2613	3	2-1	-	3	1000	12.90	59.656			
P4	CEC	2500 2734	4	2-2	-	4	1000	10.74	155.64			10mv @ 450 ps
P5	CEC	1000 2611	5	2-3	-	5	1000	12.78	63.008			
P6	H	53 TM6	6	1-2	2	6	2	0	.45313			STEAM HI - NW 65
P7	H	53 TM7	7	1-6	3	7	2	0	.05664			STEAM LO - NW 65
P8	B	53 TM2	6	1-2	2	6	2	0	.45313			STEAM HI - NW 100
P9	B	53 TM3	7	1-6	3	7	2	0	.05664			STEAM LO - NW 100
D3	BLH	50" 42702	8	1-3	7	8	1000	-.00498	.1216			
D4	BLH	50" 71471	9	2-4	-	9	1000	-.00092	.2425			
D5	BLH	300" 77332	10	2-5	-	10	1000	-.01301	1.486			
D6	H	46 TM4	11	1-4	4	11	2	0	.45313			WATER HI - NW 32
D7	H	46 TM5	12	1-4	5	12	2	0	.05664			WATER LO - NW 32
D8	B	50 TM1	12	1-4	5	12	2	0	.45313			WATER - NW 50
D19	H	46 TM4	6	1-2	2	6	2	0	.45313			THROTTLE HI - NW 32
D20	H	46 TM5	7	1-6	3	7	2	0	.05664			THROTTLE LO - NW 32
D21	B	50 TM1	7	1-6	3	7	2	0	.45313			THROTTLE - NW 32
D6	BLH	20" 39192	16	1-5	9	16	1000	-.00037	.04884			
D7	BLH	300" 44226	17	2-6	-	17	1000	-.00643	.7456			
D10	BLH	10" 43544	18	2-7	-	18	1000	-.0082	.6425			
T6			19	2-8	-	24	1000	150.4	45.28	-.1573	.00283	
T4			20	2-9	-	20	1000	150.4	45.28	-.1573	.00288	
T1	H	56 TA1	21	2-10	-	21	500	32	90.56	-.3144	.00576	STEAM - NW 65
T2	B	60 TA2	21	2-10	-	21	500	32	90.56	-.3144	.00576	STEAM - NW 100
T3	H	49 TA3	22	2-11	-	22	500	32	90.56	-.3144	.00576	WATER - NW 32
T2	B	52 TA1	22	2-11	-	22	500	32	90.56	-.3144	.00576	WATER - NW 50
T20	H	49 TA3	21	2-10	-	21	500	32	90.56	-.3144	.00576	THROTTLE NW 32
T21	B	52 TA1	21	2-10	-	21	500	32	90.56	-.3144	.00576	THROTTLE - NW 32
T3			23	2-12	-	23	1000	150.4	45.28	-.1573	.00288	
T9			25	2-13	-	25	1000	150.4	45.28	-.1573	.00288	
R1			26	1-8	13	26	1	206.24	10.24	.005		
R2			27	1-9	14	27	1	120.66	10.24	.005		
GFR R1			28	-	-	28	10v					
GFR R2			29	-	-	29	10v					
G1			31	1-10	15	31	2	0	.4			Range 3
F6			32	1-11	16	32	1000	-66.96	1788.15			
F7			33	1-11	16	33	5					Bottom
F8			34	1-13	17	34	5		AI-9			Side

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Date

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7021C	104	44/ 08:53.00 52.??	08:52.00	044- 213	-	-	0- 25- 50 75 100 0 found D9 by open this mor probably open all runs Frida 3-8 off for first 20 S
7021	109	11:30.40	11:32.00		-	-	
7022	101	12:14.25	12:15.25		-	-	Drag Disc Rdy (no FS = -.244V D9 = -.527 Q4 = +.082
7023	101	12:30.30	Abort at 12:31.08				no flow
7023	101	12:32.00	12:32.30				no flow
7024	101	12:36.35	12:37.20				Rezeroed D.D. & 1 No flow
7025	101	12:42.10	12:43.10				Same point as 7022

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7026	101 101	044/ 12:49.05 10	12:50.10	044- 2.3			T10 looks bad this
7027		12:57.35	12:58.30				↓
7028		13:08.50	09:50				↓ D9 pegged
7029		13:14.30	15:30				↓ D9 pegged
7030		13:17.20	18:20				↓ ↓
7031		13:21.00	13:22.00				↓ ↓
7032		13:25.00	26.00				↓ ↓

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7033	101 101	044 13:31.45 32.00	33.00	044 -2,3				D9 pegged Trio Bad
7034		13:36.35	37.35					
7035		14:12.00 31.50	32.00		yes	yes	yes	Prior to this bypassed D9, the bypass, 2, started operat
AI-12 7036		15:04.20	05.20		yes	yes	yes	
7037		15:30.45	31.45		yes	yes	yes	
7038		16:03.30	Abort 16:04.00		ye			
7038		16:14.50	16:24.20		yes	yes	yes	Point changed slight during run. This settled down a bit.

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7039	101	044 16:53.45	55.00	044- 2,3	No yes	No yes	yes	X SNAFU No good
7040		17:45.40			No	yes	yes	
7041		18:27.45	18:28.45	044A- 2,3	yes			CHANGE TAPES All water 38 filters out To catch tracer
7042		18:38.45						
7042 7041C		19:10.00	19:10.50					0 25 P3 offset = +6 50 75 P7 offset = + - 100 P
END OF DAY								

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Date

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan. Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7042 C	102	045/ 11:58.50	59.40	044A- 2,3	—	—	—	
7042	102	12:18.30 17	18.30		yes	—	—	All Steam PP Gsm=1000 this run
7043 AI-14		13:54.40	56.25		yes	yes	Bad Turbine	All Water
7044		15:15.50	16:50		No	yes	—	All Water
7045		15:32.05			No	yes		
7046		15:51.45 52.00	53.00		No	yes		
7047		16:05.00	06.40		No	No		

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan (Pen)	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7048	102	045/ 16:21.10	23.15	044A- 2,3	No	yes		No turbine
7049		16:32.30	16:34.25			—		no flow
7050		16:38.30	16:40.00			yes ?		Loop changed before injection??
7051		16:44.30	16:46.00			yes no chart on first shot		Does not turned off between runs. 3. Two injections a-no ch. b-loop ch then ed made
7052		16:57.25	58.00 59.00			yes		
7053		17:07.00	08.00			yes		
7054		17:14.30	17:17.00			yes		A small amount of fro dumped into system 10 sec into run, also

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Date

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Taps	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7055	102	045/ 17:19:50	17:20:50	044A- 2,3	No	No		No turbine ↓
7055C	102	17:32:25	33:15	↓				turbine starter working again af. low Temp.
								0 25 50 75 100
AT-16								

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7057C	102	047/ 8:50.45	51.30	046- 2,3				0 25 50 75 100 125
7057		09:44.10	45.25		No	No	No	AM Steam small change in para halfway through te
7058		10:19.40	21.00		yes no	No	No	Alks Wasser
7059		10:58.20	11:01.00 → 02.30		yes	No	no	68-dens (Löffel) dots on slugs
7060		11:10.45	11:12.00		yes	No		Changed to slug starting 11:00.05 Ran tapes to 11:02.3 Some pointers;
7061		12:51.30	12:53.45		No	No		
7062		13:42.30			yes no	no		D9 pugging on peak

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7063	102	13:56.40	58.40	046- 2.3	No yes	yes		
7064		14:41.00	43.15		yes	yes		T10 pb looked bad for of run (until last FS clipping on peak
7065		15:37.00	15:38.00		yes	yes		
7066		16:00.00	16:01.00		No	yes		
7067		16:38.10	41.00		yes	yes		
7068		17:03:30	17:05:50		yes	yes		
7069		17:31.35	22.20		yes	yes		

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Taps	Scan Items	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7070	102	047 17:56.10 17:57.00	58.00	046- 2.3	Yes	No		R4 clipping on strip overrange ??
7071	102	18:20.30	23.10 24.30 25.40		No			Rest tapes
707C	102	18: 53.15 53.20	54:30					0 25 50 75 100
								

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7072	102	048/ 08:30		—	yes	—	—	We found a condition in the p. we liked before startup & too on the Scanning Dens. only. P ≈ 1/2 bar, 2100°F, steam.
7073C		09:03.50 09:04.50 09:05.50	09:06.40	046- 2.3				
7073		09:22.55	23.55		yes			Turbine Kaput
7074		09:43.30			yes			All Steam Turbin D9 offset = -2.5: this run only Aller Wasser
7074C		09:46.30	09:47:20					
7075C		09:56.00	56.50	048- 2.3				END OF TAI
7076		11:25.30	26.30		yes	yes	yes	Begin OF TA.

OPERATION LOG SHEET

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Taps	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7076	102	048/ 12:30.00	32.30	048- 2,3	yes	yes	yes	Turbine Krank
7077		13:01.40	03.20		yes	yes	yes	↓
7078 A1-22		13:41.00	44.00		yes	yes	yes	↓
7079		14:12.20	13:50 14:11.4		yes	yes	yes	↓
7080		15:03.40	04.40		yes Krank	yes	yes	↓
7081		15:39.30	42.00 40.30			yes	yes	↓
7082	V	16:16.30	18:30		Krank	yes	yes	↓

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Type	Scan Demo	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7083	102	16:46.10	48.00	048- 2.3	Krank	yes	yes	Turbine Krank
7084		17:10.30	11:30			yes	—	All Steam
7085 A1-23		17:18.20	20.10			—	—	No Flow Drag Disc offs = +.361
7085c		17:49.30	51.10			—	—	0 25 50 75 100
END OF DAY								

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RTR 2797
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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan Deas	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7086C	102	051/ 10:17.00	17:50	048- 2.3	-	-	-	Turbine Kronik 0 25 50 75 100 0
7086		10:29.30 Abort 10:38.00	39.00			-	-	Steam
7087		11:20.50	11:22:30		-	-	-	Water
AI-2 7088		14:11.10	12.10		yes	yes	yes	
7089		15:00.20	01.50		yes	yes	yes	
7090		15:23.10	24.30		yes	yes	yes	
7091		16:01.30			yes	yes	yes	

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Typ	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7092	102	051/ 16:35.00	37.00	048- 2.3	yes	yes	yes	
7093		17:18.10	21.10		yes	yes	yes	
7094		18:04.20	06.30		yes	yes	yes	
7095		18:25.45	27.00		yes			
7096	✓	18:49.00	49:45		yes	No	No	STEAM
7097		19:12.40	19:13.40	051- 2.3	yes	No	No	Wasser
7097C	✓	19:42.00	47.50					END OF DATA

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D9 offset
= +.022V

051
2.3

AI-25

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Date 22 FEB 78

TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7098C	102	053/ 08:57.00	57.50	051- 2,3	—	No	—	0 25 50 75 100 Does not have Sec leader i of This run
7098		09:34.00	35.30		yes		—	Source on @ 34 ← Loop Bypass port TAPES LEFT R
7098		36.30	37.30		yes	same run	—	← All Steam ← Reserved 3-x De
7099		44.50	45.50		yes		—	← All Steam DD. quit
END of Day								

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REF 2784

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Date

23 Feb 78

TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7100C	102	054✓ 10:10.30	11:45	051- 2,3	—	No	—	0 25 50 75 100 0 New DDT installed
7100		10:35.00 10:35.00	10:36.00		yes		—	D.D. offset before run = -.300V. Have seen offset = .35V All Steam Tapes start w/ den 10:34.00
7101		11:10.50	11.50		yes		—	All water
AT-27 7102		11:56.40	57.40		yes		yes	Tape off at 57.50. Surv about that
7103		12:30.00	31.30		yes		yes	
7104		13:55.50	27.20		yes			
7105	✓	13:57.55	59.20		yes	✓	yes	

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OPERATION LOG SHEET

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Date 23 Feb 78

TSN	SETUP REF. NO.	IRIG.START	IRIG.END	TAPE	SCAN Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7106	102	054/ 14:43.20	44.30	051- 2-3	yes	No	yes	
7107		15:47.10	15:49.30		No		No	All water CAL
7108		15:58.55	16:00.00		No		No	
7109		16:05.20	16:06.30		No		No	Tapes off at 16:06 STABLE from 05.50 to 06.
7110		16:12.15	13.30		No		No	
7111		16:17.10	18.10		No		No	No Flow
7111 C		16:28.40	29.30					END of

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KFK 2784

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OPERATION LOG SHEET

Date 24 Feb 1978

TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7112c	102	055/ 09:57.10	58.00	051- 2.3	—	No	—	0 25 50 75 100 D.O. offset = + Turb " = +.
7112		10:19.00	10:20.30		No Yes		—	All STEAM
7113		11:00.00	11:01.00		Yes		—	All STEAM Reset 3-8 Dens This run
AL-29 7114		11:33.00	11:36.00		No		—	All WATER Scan Dens. data may be because of slight change water temp.
7115		12:15.50	12:17.00		Yes		—	All Water
7116		12:33.50	12:35.50		No		—	All Water
7117		12:51.30	52.00		No		—	All Water

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2.4

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	TEMP	WIND	RADIO TRACER DATA	IMP. PROBE DATA		COMMENTS
7123	102	0551 17:08:45	07.45	055- 17:08:45	100	NO	(4)	—	Throttling
7124		17:39.40	41.10		yes		—	—	All Steam
7125		17:58.40	18:00.00		No		No		Water
7125C		18:05.10 18:12.30	06.30 13.20					D9 offset = +.019V	0 25 50 75 100 °
END OF DAY									

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Date 27 Feb 78

TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7126c	102	058/ 10:56.40	57.55	055-2	—	No	—	0 25 50 75 100 0
7126		11:01.30	02.30	↓	yes		—	All Steam Cal TR #3 down Data on TR #2 only
7127 A1-32		11:29.40 11:33.40	ABORT 34.45	055-2.3	yes		—	Now using TR #4 Tape 055-3 to TR All water
7127c		11:38.30	Abort		—		—	0 25 50 75 100 0 Q4 cal bad D9 cal bad
7127c		11:51.10 12:17.30	18:20		—		—	
7128		12:42.15			yes			
7129		13:23:00	13:25:00		yes			

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Date

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TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Tapes	Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
71294	102	13:39:45	41:45	055- 2.1)	yes	No yes	yes	
7130		13:53:30	54:30		yes		yes	
7131		14:27.45	28.45		yes		yes	
7132		14:52:00	53:00		yes		yes	no strips
7133		15:24.30	25:30					
7134		15:55.40	56.40		yes		yes	
7135		16:26:30	26:30		yes		yes	

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Date 27 Feb 78

TSN	SETUP REF. NO.	IRIG.START	IRIG.END	Topo	Scan Down	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7136	102	058/ 16:47.45	48.45	058- 2.3	yes	No	yes	
7137		17:10.00			yes		yes	
7138		17:35.15	36.45		yes		yes	
AI-34 7138 c		18:01.30	02.20		—		—	
7139 c		18:08.15	09.05	058- 2.3	—		—	
7139		18:11.50	12.50		yes		yes	
7140		18:37.30			no	✓	11	Tr. +

058-2.3
058-2.3
058-2.3
058-2.3
058-2.3
058-2.3
058-2.3
058-2.3
058-2.3
058-2.3

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Date 27 Feb 78

TSN	SETUP REF. NO.	IRIG.START	IRIG.END		Scan Dens	RADIO TRACER DATA	IMP. PROBE DATA	COMMENTS
7141	102	058/19:11.00 16:47.45	16.30 48.45	055- 2.3	yes	No	No	T4 looks to be going Kspit Steam Data unstable 19:13.40, T4 good at
7142		19:42.20 42.20	43.20		yes	No	No	T10 bad T4 good Water D9 offset after run = 2 F5 offset after run = -3
7143 A1-B C		19:58.00	58.50		No	No	No	0. 25 50 75 100 3-8 densitometer measured cold this morning = 25%

END OF TEST

scooby-doo by bee boy

LTR LO-00-80-113
KFK 2784

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KFK 2784

APPENDIX 2

IRB REFERENCE VALUES

Test No											
Data											
Time	7024	7025	7026	7027	7028	7029	7030	7031	7032	7033	7034
P_{TS} (bar)	48.95	48.71	49.03	48.23	48.55	49.63	48.15	48.71	48.64	47.82	47.11
T_{TS} (°C)	262.62	262.49	262.49	262.61	262.61	262.19	261.44	262.61	262.49	261.4	261.4
C_W (m/s)	0.329	0.331	0.538	0.543	1.266	0.724	0.941	0.68	1.80	0.12	
C_S (m/s)	0.139	0.139	0.142	0.057	0.018	0.225	0.242	0.194	1.44	0.14	
$\dot{m}$ (kg/s)	0.903	0.908	1.482	1.501	3.45	1.999	2.611	2.952	3.404	2.01	1.5
X (%)	0.38	0.38	0.83	0.33	7.53	0.96	0.184	0.57	4.0	4.0	0.8
α (%)	40.58	0.11	20.9	9.42	0.14	23.7	21.0	15.2	76.9	16	40
Flow Regime											
T_{DDT} (°C)											
V_T (m/s)	0.17	0.27	0.33	0.46	1.15	0.65	0.86	1.01	1.32	0.72	0.1
R_4 (kg/m³)	843	814	819	808	808	744	805	811	805	803	77
R_5 (kg/m³)	852	825	827	819	824	817	819	822	825	821	811
R_6 (kg/m³)	879	845	848	852	852	826	856	856	860	854	831
$\bar{P}_D$ (kg/m³)	856	826	830	924	826	813	823	827	828	824	812
PV^2 (kg/ms²)	19	53	55	172	994	328	572	777	1157	355	11
$\bar{P}_{SD}$ (kg/m³)											
$\dot{m}_{T,D}$ (kg/s)	0.45	0.73	0.75	1.32	3.17	1.81	2.40	2.80	3.42	1.89	1.0
$\dot{m}_{T,DB}$ (kg/s)					2.8	0.33	1.70	2.29	3.42	0.73	
$\dot{m}_{D,DB}$ (kg/s)					2.98	0.77	2.02	2.54	3.42	1.33	
V_W (m/s)											
V_S (m/s)											
$\dot{m}$ (kg/s)											
ρ (kg/m³)					A2-1						

Measured Values IRB

Measured Values INEL

Values

TEST NR.		7035	7036	7037	7038	7039	7040	7041	7042		
Data	Time	14 ³²	15 ⁰⁵	15 ³¹	16 ¹⁵	16 ⁵³	17 ⁴⁵	18 ²⁷		LTR	LO-00-80-113
P _{TS} (bar)		42.27	42.67	42.10	42.02	42.02	42.30	55.4		KFK	2784
T _{TS} (°C)		253.5	254.9	253.5	253.5	253.5	253.5	269.8			
C _W (m/s)		0.059	1.317	1.39	1.39	1.31	1.26	0.846			
C _S (m/s)		2.05	1.92	1.28	0.027	1.57	2.99	0.035			
ṁ (kg/s)		3.609	3.813	3.852	3.88	3.75	3.72	2.283			
X (%)		4.22	3.82	2.48	0.05	3.12	5.98	0.37			
α (%)		97.2	59.3	48	1.9	55	70	9.1			
Flow Regime											
T _{DDT} (°C)											
V _T (m/s)		2.80	2.45	1.88	1.42		3.43	0.76			
R _L (kg/m ³)		286	308	411	596		411	684			
R _S (kg/m ³)		390	433	505	726		287	787			
R _G (kg/m ³)		588	623	722	859		487	762			
ρ _D (kg/m ³)		407	442	530	717		383	746			
ρV ² (kg/ms ²)											
ρ _{SD} (kg/m ³)											
ṁ _{T.D} (kg/s)		3.98	3.76	3.48	3.56		4.60	1.97			
ṁ _{T.DB} (kg/s)		3.42	3.26	4.04	4.19		2.56	2.14			
ṁ _{D.DB} (kg/s)		3.70	3.51	3.75	3.87		3.43	2.05			
V _W (m/s)		0.1	0.5	0.4	0.1	—	—	0.3			
V _S (m/s)		0.1	1.2	1.5	1.1	—	0.1	0.1			
ṁ (kg/s)											
ρ (kg/m ³)											

Data Time	7042	7043	7044	7045	7046	7047	7048	7049	7050	7051	7052
	1218	1354	1516	1532	1552	1605	1621	1632	1638	1644	1650
P_{TS} (bar)			38.26	38.01	38.18	38.67	38.50		38.16	38.16	38.16
T_{TS} (°C)			247.69	247.69	247.69	247.69	247.69		247.69	247.69	247.69
C_w (m/s)			1.11	0.934	0.674	0.357	0.356		0.402	0.404	0.404
C_s (m/s)			1.21	1.02	0.369	0.169	0.051		0.143	0.422	0.404
$\dot{m}$ (kg/s)			3.201	2.859	1.911	1.454	1.00		1.304	1.317	1.317
X (%)			2.55	2.4	1.3	0.80	0.35		0.70	0.67	0.67
α (%)			52.1	50.1	35.4	31.9	12.5		23.64	38.9	31
Flow Regime											
T_{DDT} (°C)											
V_T (m/s)	2.86	0.139	0.142	0.139	0.139	0.139	0.136	0.136	0.136	0.135	0.13
R_L (kg/m ³)	22.80	779	779	784	813	801	798	830	810	815	799
R_S (kg/m ³)	21.71	793	793	798	814	811	809	833	817	817	817
R_6 (kg/m ³)	14.74	858	866	862	854	866	884	888	879	862	880
$\bar{p}_D$ (kg/m ³)	20.24	805	801	810	824	822	825	846	828	828	823
ρV^2 (kg/m s ²)											
$\bar{p}_{SD}$ (kg/m ³)											
$\dot{m}_{T+D}$ (kg/s)											
$\dot{m}_{T+DB}$ (kg/s)											
$\dot{m}_{D+DB}$ (kg/s)	0.215	3.90	3.17	2.95	1.87	1.29	0.52	—	0.71	1.74	2.01
V_w (m/s)											
V_s (m/s)											
$\dot{m}$ (kg/s)											
ρ (kg/m ³)					A2-3						

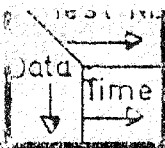
Measured Values IRB

Measured Values INEL

Values

Test No.		7053	7054	LTR LO-00-80-113			
Data	Time			KFK 2784			
P_{TS} (bar)		39.015	37.52				
T_{TS} (°C)		249.2	246.2				
C_w (m/s)		1.148	1.296				
C_s (m/s)		0.131	0.902				
$\dot{m}$ (kg/s)		3.366	3.711				
X (%)		0.27	1.6				
α (%)		9.9	41.0				
Flow Regime							
T_{DDT} (°C)							
V_f (m/s)		0.134	0.134				
R_4 (kg/m³)		801	801				
R_5 (kg/m³)		809	811				
R_6 (kg/m³)		873	873				
$\bar{p}_D$ (kg/m³)		823	824				
ρV^2 (kg/ms²)							
$\bar{p}_{SD}$ (kg/m³)							
$\dot{m}_{T,D}$ (kg/s)							
$\dot{m}_{T,DB}$ (kg/s)							
$\dot{m}_{D,DB}$ (kg/s)		3.49	3.83				
V_w (m/s)							
V_s (m/s)		3.96	2.857				
$\dot{m}$ (kg/s)							
ρ (kg/m³)							

KFK 2/24 LTR L 00-80-113



Measured Values IRB

Measured Values INEL

Values

	7059	7060	7061	7062	7063	7064	7065	7066	7067	7068	7069
Data	1057	1111	1253	1343	1358	1447	1535	1600	1640	1723	1757
Time											
P_{TS} (bar)	15.15	15.56	16.04	15.79	16.12	14.09	15.00	16.12	15.15	15.34	17
T_{TS} (°C)	195.6	198.5	199.27	197.8	201.4	194.18	200.36	198.9	195.49	195.49	183
C_W (m/s)	1.563	1.562	1.568	1.539	1.534	1.221	1.089	1.113	1.121	1.111	1
C_S (m/s)	2.022	1.912	0.955	2.693	2.833	8.851	1.908	0.282	1.347	2.615	5.1
$\dot{m}$ (kg/s)	4.782	4.769	4.754	4.717	4.704	3.931	3.337	3.362	3.426	3.40	3.0
X (%)	1.1	1.1	0.6	1.6	1.7	5.6	1.6	0.2	1.1	2.1	1.1
α (%)	56.4	55.0	37.9	63.6	64.9	87.9	63.7	20.2	54.6	76.2	91.1
Flow Regime								1			
T_{DDT} (°C)	203.9	204	206	203	206	206	200	205	203	205	192
V_T (m/s)	1.736	2.161	1.66	3.51	2.80	7.41	1.45	1.04	1.40	2.45	7.8
R_L (kg/m³)	638	486	638	256	322	131	556	763	390	214	73
R_S (kg/m³)	721	552	721	398	451	267	430	846	540	377	237
R_6 (kg/m³)	834	740	823	509	579	343	703	827	740	343	320
$\bar{P}_D$ (kg/m³)	723	579	548	379	440	240	556	812	542	365	20
P_{SD}^2 (kg/ms²)	2978	3209	2517	3440	3440	3204	1594	1156	1594	2056	251
$\bar{P}_{SD}$ (kg/m³)											
$\dot{m}_{T,D}$ (kg/s)	4.38	4.37	3.19	4.65	4.32	6.23	2.82	2.96	2.80	3.12	5.81
$\dot{m}_{T,DB}$ (kg/s)	5.99	5.19	5.28	3.42	4.29	1.51	3.84	3.88	3.76	2.94	1.12
$\dot{m}_{D,DB}$ (kg/s)	5.12	4.76	4.11	3.99	4.30	3.07	3.29	3.39	3.25	3.03	2.51
V_W (m/s)	16.67	33.23	36.04	56.0	5.00	73.01	3.5	1.07	1.07	1.07	3.0
V_S (m/s)	2.44	2.44	1.046	1.317	1.317	2.162	2.162	4.073	1.07	1.07	1.07
$\dot{m}$ (kg/s)											
p (kg/m³)											

Test No.										
Data										
Time	7076	7077	7078	7079	7080	7081	7082	7083	7084	7085
P_{TS} (bar)	17.66	17.66	16.85	15.88	16.37 14.31	14.34	15.46	16.25 20.143	LTR LO-00-80-113	
T_{TS} (°C)	203.23	203.22	201.4	201.1	198.9	194.91	198.18	201.43	KFK	
C_W (m/s)	1.342	1.33	1.317	1.256	1.275	1.213	0.747	0.482		
C_S (m/s)	0.625	1.372	2.244	3.559	9.813	15.75	3.766	0.434		
$\dot{m}$ (kg/s)	4.038	4.026	4.024	3.887	4.123	4.081	2.353	2.366		
X (%)	0.5	1.1	1.7	2.6	6.9	—	4.4	0.5		
α (%)	31.8	50.8	63.0	73.9	88.5	—	83.5	35.7		
Flow Regime										
T_{DDT} (°C)	212	210	208	205	205	201				
V_T (m/s)			Turbine stop & c.f. functioning!							
R_L (kg/m ³)	688	498	338	253	176	125	188			
R_S (kg/m ³)	738	541	426	323	245	195	292			
R_6 (kg/m ³)	839	747	668	505	426	265	441			
$\bar{p}_D$ (kg/m ³)	748	581	460	347	269	191	297			
PV_{SD}^2 (kg/ms ²)	1710	2125	2125	1917	3578	6692	776			
$\bar{p}_{SD}$ (kg/m ³)										
$\dot{m}_{T,D}$ (kg/s)										
$\dot{m}_{T,DB}$ (kg/s)										
$\dot{m}_{D,DB}$ (kg/s)	3.45	3.88	3.46	2.85	3.43	3.95	1.68			
V_W (m/s)										
V_S (m/s)										
$\dot{m}$ (kg/s)										
ρ (kg/m ³)										

Measured Values IRB

Measured Values INEL

Values

Data	7088	7089	7090	7091	7092	7093	7094	7095	7096	7097	7098
Time	14:14	14:54	15:19	16:02	16:35	17:15	18:04	18:26	18:44	19:04	19:24
P_{ts} (bar)	15.88	17.58	17.177	17.50	14.746	14.204	17.258	17.144			
T_{ts} (°C)	193.54	204.66	202.87	205.74	194.91	206.88	201.79	203.46			
C_w (m/s)	0.637	0.666	0.663	0.718	0.750	0.680	0.840	0.837			
C (m/s)	1.491	0.264	1.039	3.937	9.241	0.917	1.223	0.287			
$\dot{m}$ (kg/s)	1.962	2.002	2.022	2.272	2.515	0.865	2.557	2.516			
X (%)	2.1	0.4	1.6	5.3	9.6	3.6	15	0.4			
α (%)	70.1	28.4	61.0	84.6	92.5	76.6	59.3	25.6			
Flow Regime											
T_{DDT} (°C)	206	210			203	214	210	209			
V_T (m/s)											
R_4 (kg/m³)	387	664	435	231	153	381	441	826			
R_5 (kg/m³)	460	777	521	310	221	460	516	875			
R_6 (kg/m³)	681	870	135	439	336	645	717	862			
$\bar{p}_D$ (kg/m³)	493	762	551	317	228	484	546	—			
pV^2_{2D} (kg/m³)	568	465	569	672	1814	-531	880	1-			
$\bar{p}_{SD}$ (kg/m³)											
$\dot{m}_{1,D}$ (kg/s)											
$\dot{m}_{T,DB}$ (kg/s)											
$\dot{m}_{D,DB}$ (kg/s)	1.55	2.08	1.96	1.61	2.25	—	2.42	—			
V_W (m/s)											
V_S (m/s)											
$\dot{m}$ (kg/s)											
ρ (kg/m³)											

Measured Values IRB

Measured Values INEL

Values

Test No.	7102	7103	7104	7105	7106	7107	7108	7109	7110	7111	7112
Data Time	1156	1230	1326	1358	1432	1547	1559	1605	1612	1617	
P_{TS} (bar)	18.312	16.852	17.50	16.366	17.744	15.313	14.62	15.77	14.42		
T_{TS} (°C)	207.54	202.51	202.87	199.27	202.5	198.34	194.19	200.76	196.4		
C_W (m/s)	1.580	1.599	1.584	1.565	1.361	1.505	0.971	0.470	0.282		
C_S (m/s)	2.132	0.522	1.513	3.237	8.721	8.85	3.27	0.737	0.118		
$\dot{m}$ (kg/s)	4.788	4.821	4.794	4.804	4.346	4.802	3.040	1.443	0.78		
X (%)	1.4	0.3	1.0	1.9	6.3	5.0	2.6	1.47	0.4		
α_{visum} (%)	57.4	24.6	48.9	67.4	86.5	85.5	77.1	61.7	31.8		
Flow Regime											
T_{ODT} (°C)											
V_T (m/s)	4.77	3.15	4.17	6.48							
R_L (kg/m ³)	375	771	484	317							
R_S (kg/m ³)	462	809	566	395							
R_B (kg/m ³)	710	885	783	551							
$\bar{p}_D$ (kg/m ³)	498	803	595	410							
$\overline{pV^2}$ (kg/ms ²)	6603	4937	6603	7917							
$\bar{p}_{SD}$ (kg/m ³)											
$\dot{m}_{T,D}$ (kg/s)	8.29	8.83	8.67	8.71							
$\dot{m}_{T,DB}$ (kg/s)	4.84	5.48	5.53	4.55							
$\dot{m}_{D,DB}$ (kg/s)	6.33	6.96	6.93	6.30							
V_W (m/s)	112.7	6.77	3.77	5.77							
V_S (m/s)	1.77	1.534	2.13	1.828							
$\dot{m}$ (kg/s)											
ρ (kg/m ³)											

Date	Time	7112	7113	7114	7115	7116	7117	7118	7119	7120	7121	7122
		10 ¹⁹	11 ⁰⁰	11 ³³	12 ¹⁶	12 ³⁴	12 ⁵¹	13 ⁰²	14 ¹⁴	15 ⁰²	15 ¹⁵	15 ³⁰
ρ_s (kg/l)				40.55	41.365	42.71	40.47	40.302	46.47	41.61	40.21	38.5
ρ_s (%)				213.64	215.79	222.26	224.71	225.84	205.45	248.11	248.11	240
C_w (m/s)				1.805	1.548	1.263	0.985	0.678	1.579	1.649	1.65	1.51
C_s (m/s)				-5.784	-4.832	-3.227	-2.304	-1.357	0.542	0.38	1.192	2.13
m (kg/s)				4.615	3.951	3.286	2.580	1.656	4.458	4.610	4.648	4.0
X (%)				-8.9	-8.9	-7.0	-6.3	-5.7	1.3	0.6	2.2	3.0
a (%)				145.3	147.1	164.0	174.7	188.5	35.7	18.7	11.0	1.9
Flow Regime												
T_{tot} (°C)												
V_t (m/s)					1.058	0.881	0.687	0.434	3.88	3.67	5.48	5.9
R_1 (kg/m ³)									472	545	333	302
R_2 (kg/m ³)									563	632	487	509
R_3 (kg/m ³)									743	746	610	580
R_4 (kg/m ³)									579	633	447	411
$\rho V^2 D^2$ (kg/m ³)					0.260	0.110	-0.031	-0.172	5727	5113	5726	610
ρ_{sp} (kg/m ³)												
ρ_{sp} (kg/s)									7.86	8.11	8.57	8.65
ρ_{sp} (kg/s)									5.15	4.87	3.65	4.3
ρ_{sp} (kg/s)									6.36	6.23	5.89	6.1
V_t (m/s)												
V_s (m/s)												
m (kg/s)												
p (kg/m ³)												

Measured Values IRB

Measured Values INEL

Values

Date	7/28	7/29	7/30	7/31	7/32	7/33	7/34	7/35	7/36	7/37	7/38
Time	1242	1339	1353	1427	1452	1524	1555	1620	1641	1710	1717
P_{TS} (bar)	42.59	38.91	35.24	44.37	41.938	44.04	46.78	43.32	41.035	38.34	37.7
T_{TS} (°C)	248.5	244.16	237.3	249.9	247.75	251.34	252.78	250.20	244.5	244.16	242
C_W (m/s)	1.060	1.026	1.032	1.154	1.090	1.094	1.093	0.770	0.762	0.831	0.8
C_S (m/s)	1.931	3.757	4.872	1.266	0.636	0.252	0.134	0.099	0.239	0.748	1.2
$\dot{m}$ (kg/s)	3.083	3.129	3.219	3.283	3.073	3.038	3.066	2.137	2.137	2.377	2.1
X (%)	4.7	8.2	9.3	3.0	1.5	1.0	0.4	1.0	0.8	2.1	3.1
α (%)	64.6	78.5	82.5	52.3	36.8	18.7	10.9	11.4	23.2	47.4	59.1
Flow Rate											
T_{DPT} (°C)	256	250		258	253	258	250	256	254	250	250
V_T (m/s)	-	10.5		3.93	2.81	2.34	2.14	1.54	1.55	1.62	2.31
R_4 (kg/m³)	316	224		359	501	557	569	622	545	484	381
P_5 (kg/m³)	376	275		451	606	647	722	712	671	616	49
R_5 (kg/m³)	545	407		587	707	740	766	777	785	763	61
P_D (kg/m³)	400	293		456	596	641	681	699	658	610	48
PV_{PD}^2 (kg/m³)	3097	3535		2221	1432	15193	1344	1344	1676	-409	-584
P_{SD} (kg/m³)											
$\dot{m}_{P.D}$ (kg/s)		10.71		6.26	5.86	5.23	5.10	3.78	3.66	3.45	3.1
$\dot{m}_{P.DB}$ (kg/s)		1.178		1.97	1.78	2.27	2.19				0.7
$\dot{m}_{D.DB}$ (kg/s)	3.89	3.55		3.51	3.23	3.45	3.34				1.6
V_W (m/s)											
V_S (m/s)	1.377	1.15		1.1	1.187	0.7					
$\dot{m}$ (kg/s)											
ρ (kg/m³)											

Pre-evaluation of the velocity-measurement with Radiotracer KFK 2784
(Results of a manual evaluation)

Test-number (LIT)	time (MEZ)	steamvelocity (m/s)	liquidvelocity (m/s)	date
157	10.56	10,2	3,2	4.11.77
158	11.37	4,8	1,4	
158 b	11.40	5,1	1,4	
159	12.00	5,2	1,35	
160	12.22	10,0	2,3	
161	13.01	10,0	2,5	
162	13.54	1,2	1,15	
163	14.22	1,1	0,6	
164	14.48	1,4	2,0	
165	15.16	10,0	10,0	
166	15.32	7,3	only steam	
167	15.49	3,8	" "	
168	16.30	5,2	" "	
169	16.58	5,3	" "	
170	17.17	1,0	1,2	
171	17.38	1,1	1,9	
172	17.56	1,2	0,67	
173	18.14	not evaluated		10.11.77
174	11.59	11,8	10,8	
175	12.49	5,8	4,1	
176	13.23	1,7	2,1	
177	13.26	2,0	1,1	
178	13.38	1,6	1,2	
179	14.06	6,8	2,5	
180	14.31	10,5	4,8	
181	15.34	2,1	2,5	
182	15.55	2,3	2,5	
183	16.31	8,0	5,5	
184	16.55	4,4	3,2	
185	17.14	6,0	4,7	
186	17.33	8,7	7,0	
187	17.44	10,4	8,5	
188	18.10	6,9	4,5	
189	18.22	A2-13	not evaluated	

Pre-evaluation of the velocity-measurement with Radiotracer
(Results of a manual evaluation)

Test-number (LIT)	time (MEZ)	steamvelocity (m/s)	liquidvelocity (m/s)	date
190	11.04	8,7	6,0	↑ 15.11.77 ↓
191	11.24	3,0	3,0	
192	12.11	1,6	1,2	
193	12.32	2,1	2,2	
194	12.59	6,0	3,3	
195	13.15	4,6	3,8	
196	13.59	6,0	4,5	
197	15.00	7,6	6,0	
198	15.49	5,2	3,8	
199	16.10	3,1	2,9	
200 a	16.59	7,4	5,4	
200 b	16.59	7,3	5,8	
201	17.31	not evaluated		
202-210	no manual evaluation because of an experimental cross-correlation			18.11.77
211-215	not evaluated			2.12.77
216	12.49	10,3	9,5	↑ 6.12.77 ↓
217	13.14	6,5	5,0	
218	14.09	3,4	2,9	
219	14.45	1,7	2,3	
220	15.56	1,2	1,2	
221	16.24	not evaluated		

Pre-evaluation of the velocity-measurement with Radiotracer
(Results of a manual evaluation)

Test-number (LIT)	time (MEZ)	steamvelocity (m/s)	liquidvelocity (m/s)	date
222	14.07		2,5	13.12.77
223	14.59		1,6	
224	15.17	no Ar-tracer	1,7	
225	15.43		5,1	
226	16.03		3,6	
227	16.23		2,4	
228	17.18		1,1	
229	17.35		1,1	
230	18.04		0,54	
231	18.27		1,7	
232	11.38	1,5	1,1	15.12.77
233	12.11	1,4	1,1	
234	12.37	40,0	33,0	
235	13.02	4,6	3,0	
236	13.23	12,9	3,8	
237	13.43	4,0	4,0	
238	14.10	not evaluated	31,0	
239	14.31	2,9	3,2	
240	15.09	2,7	2,7	
241	15.27	1,9	1,4	
242	16.02	7,0	1,6	
243	16.19	2,0	2,0	
244	16.40	1,6	2,2	
245	16.54	36,0	28,0	
246	17.29	28,3	only steam	
247	17.44	56,0	" "	
248	18.07	not evaluated		
249	18.25	" "		

Pre-evaluation of the velocity-measurement with Radiotracer FK 2784
(Results of a manual evaluation)

Test-number (LIT)	time (MEZ)	steamvelocity (m/s)	liquidvelocity (m/s)	date
250	13.50	12,8	no Mn-tracer	19.12.77
251	14.20	6,9		
252	14.45	4,2		
253	15.03	3,01		
254	15.25	1,2		
255	15.53	2,8		
256	16.22	11,9		
257	16.45	6,2		
258	17.13	4,0		
259	17.51	2,4		
260	18.05	not evaluated		

LTR LO-00-80-113

KFL 2784

APPENDIX 3

INSTRUMENT CALIBRATION DATA

TABLE A3-1 CALIBRATION DATA

Calibration I.D.	Run I.D.	Turbine Velocity (m/s)	Turbine Output (volts)	Momentum Flux (kg/ms ²)	DD Output (volts)
1. All cold water MDTT	7000	0.0	0.0355		
	7001	1.0	0.7255	1000.0	0.8162
	7002	2.0	1.378	4000.0	2.329
	7003	3.0	1.879	9000.0	4.199
	7004	4.0	2.746		
	7005	5.0	3.469		
	7006	6.0	4.244		
	7007	7.0	4.941		
	7008	8.0	5.720		
	7011	8.0	5.662		
	7012	7.0	4.978		
	7013	6.4	4.558		
	7014	5.5	3.896		
	7015	4.56	3.191		
	7016	3.43	2.385		
	7017	2.54	1.732		
	7018			6450.0	3.387
	7019	1.63	1.122	2657.0	1.488
	7020	0.0	0.101		
2. All cold water Plenum DTT	7107	1.59	1.278	2181.0	0.308
	7108	1.00	0.841	874.0	-0.108
	7109	0.48	0.408	197.0	-0.392
	7110	0.23	0.122	47.0	0.602

TABLE A3-1 CALIBRATION DATA

Calibration I.D.	Run I.D.	Turbine Velocity (m/s)	Turbine Output (volts)	Momentum Flux ₂ (kg/ms ²)	DD Output (volts)
3. All hot water	7026			227.0	0.3122
MDTT	7027	0.53	0.2868		
	7028	1.21	0.7456	1192.0	0.7939
	7029	0.70	0.4283	398.9	0.4524
	7030	0.92	0.5686	689.0	0.5921
	7031	1.04	0.6607	880.4	0.6995
	7032	1.30	0.8307	1376.0	0.9260
	7033	0.71	0.4540	410.3	0.4952
	7034	0.56	0.2572	255.3	0.3598
4. All hot water	7114	1.66	1.203	2186.0	0.271
Plenum DTT	7115	1.42	1.033	1602.0	0.118
	7116	1.18	0.856	1108.0	-0.046
	7117	0.93	0.671	683.0	-0.197
	7118	0.59	0.409	281.0	-0.359

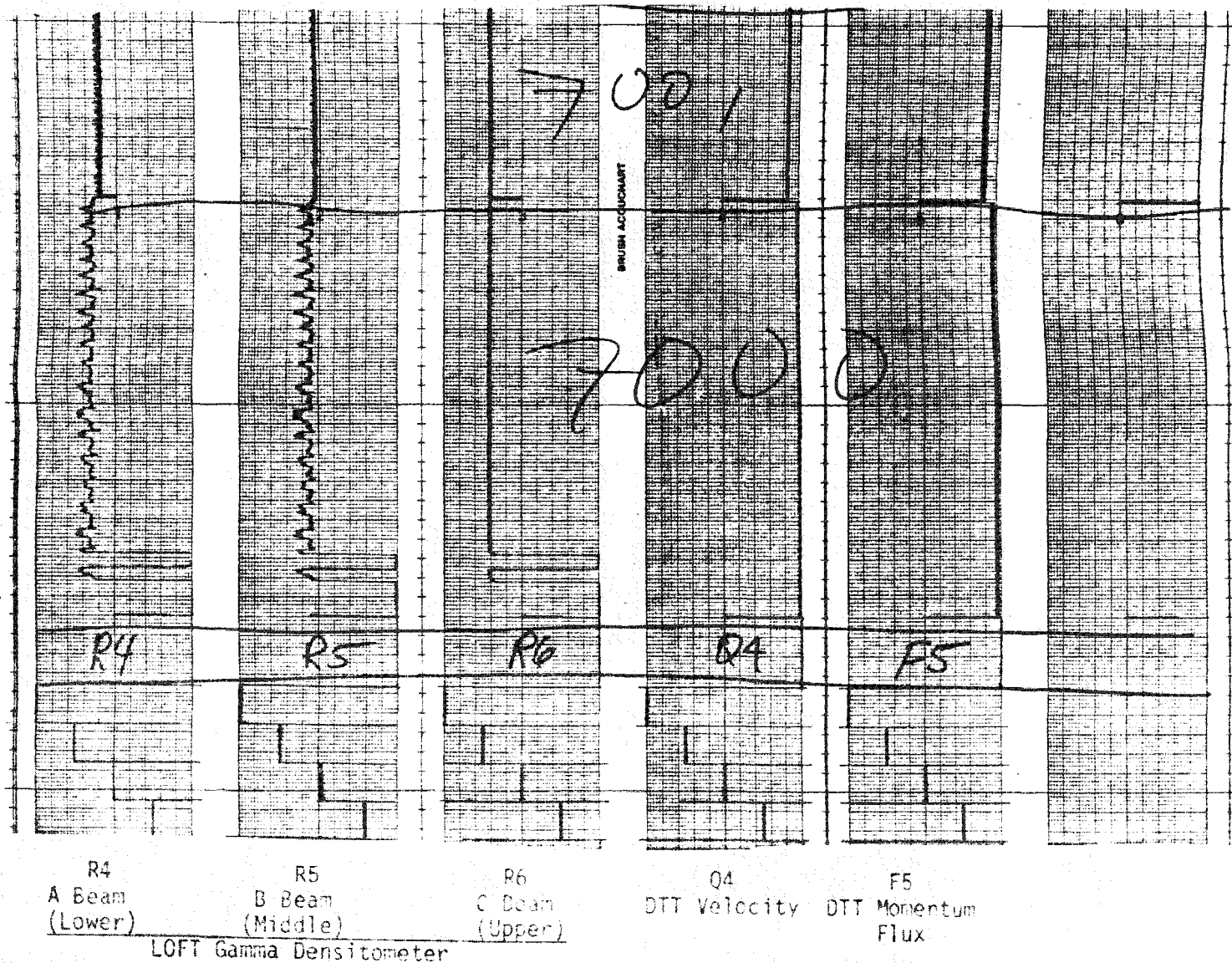
LTR L0-00-80-113

KFK 2784

APPENDIX 4

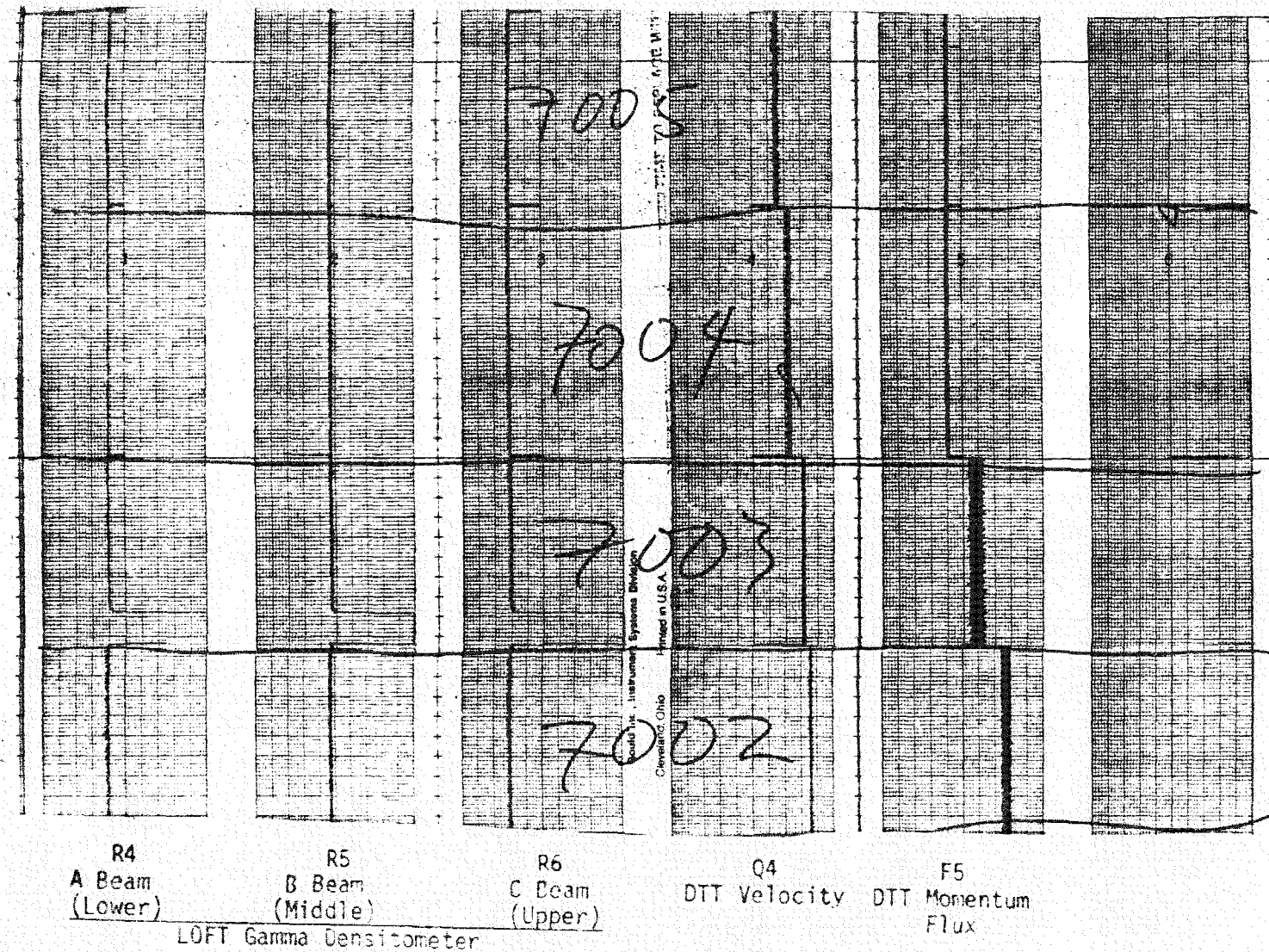
EG&G STRIP CHART RECORDINGS (VOLTAGES)

A4-1



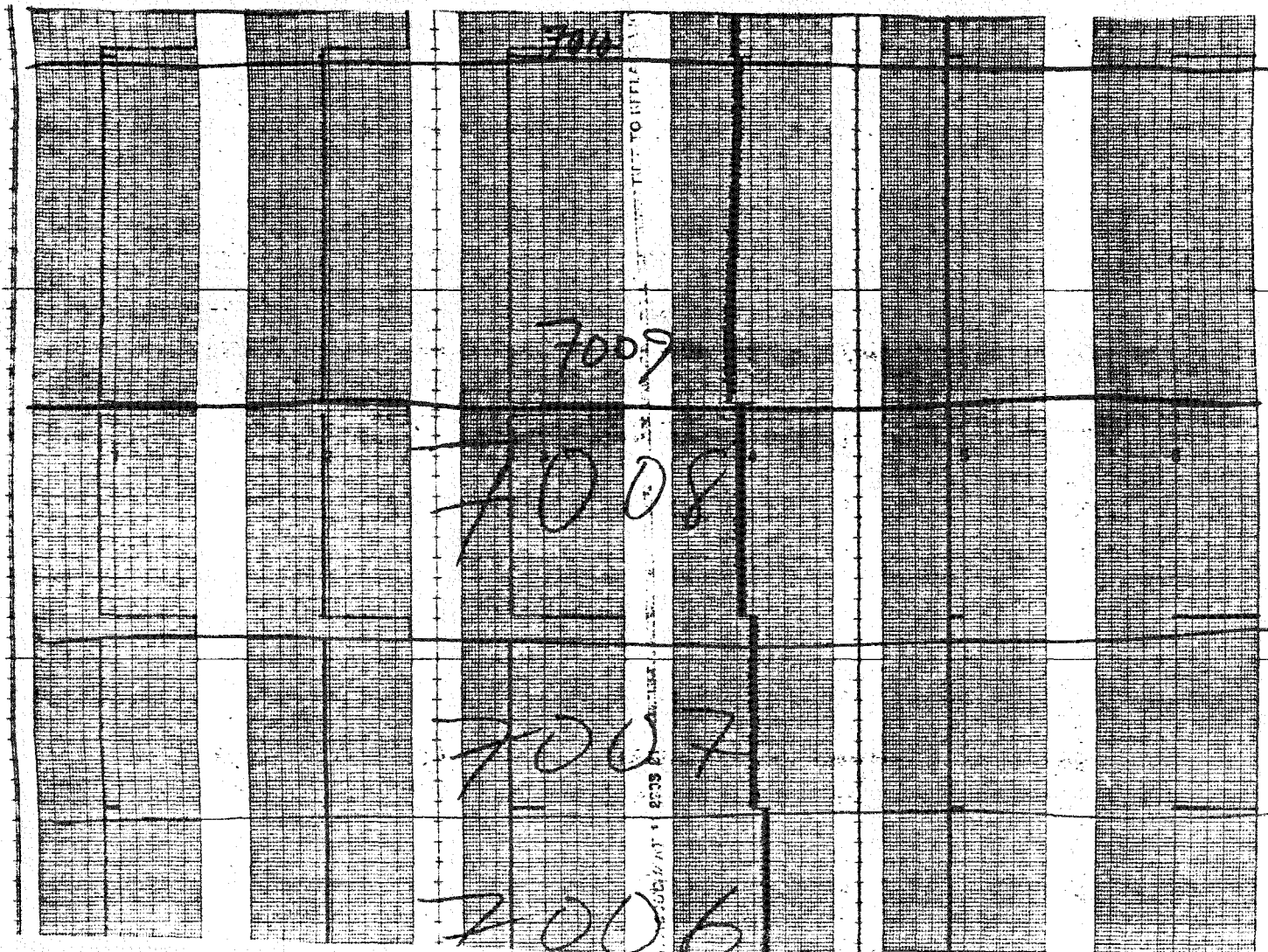
LTR LO-00-80-113
KFK 2004

A4-2



LTR LO-00-80-113

A4-3



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

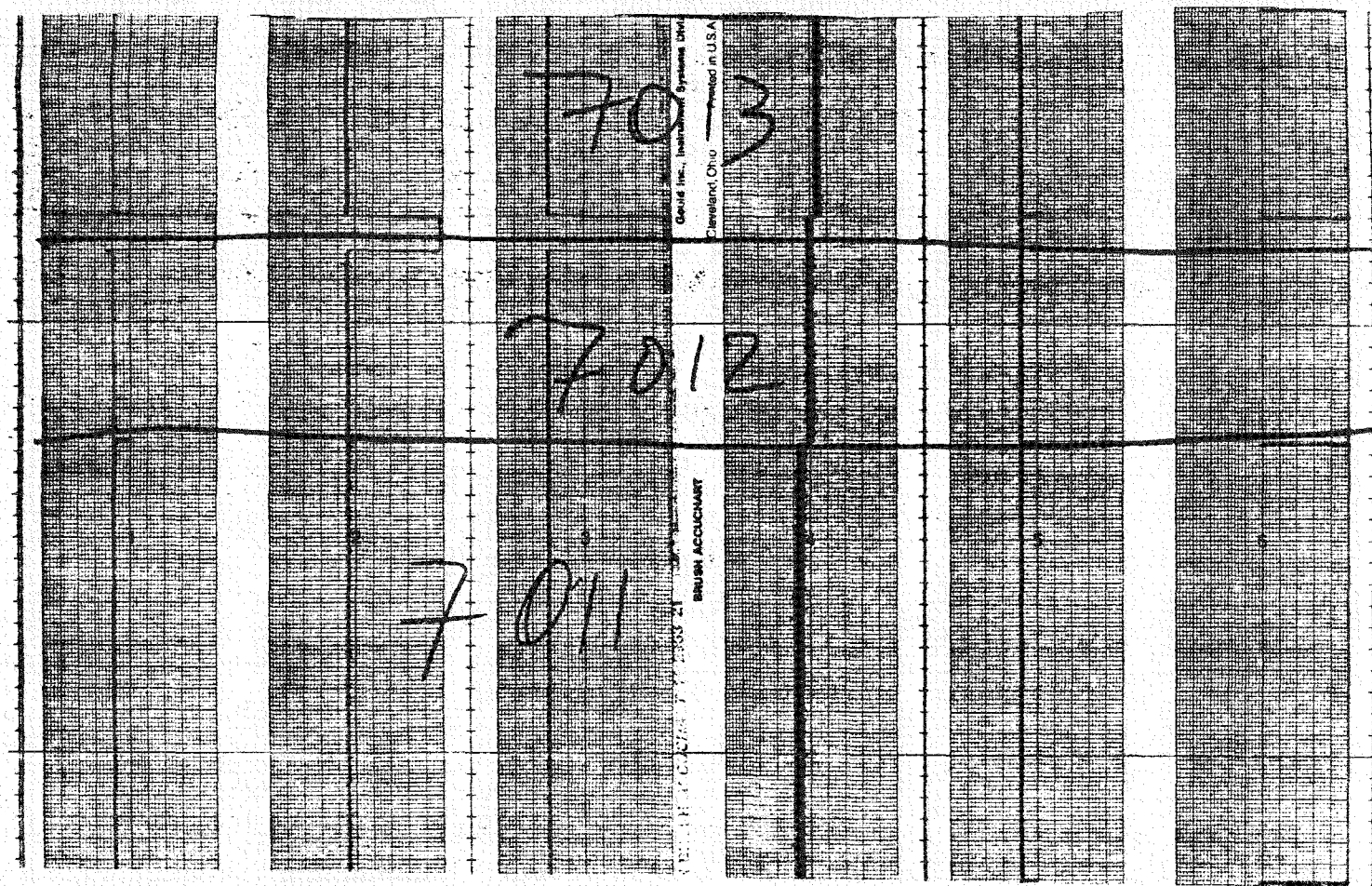
Q4
DTT Velocity

F5
DTT Momentum
Flux

LOFT Gamma Densitometer

LTR LO-00-80-113

A4-4



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

Q4
DTT Velocity

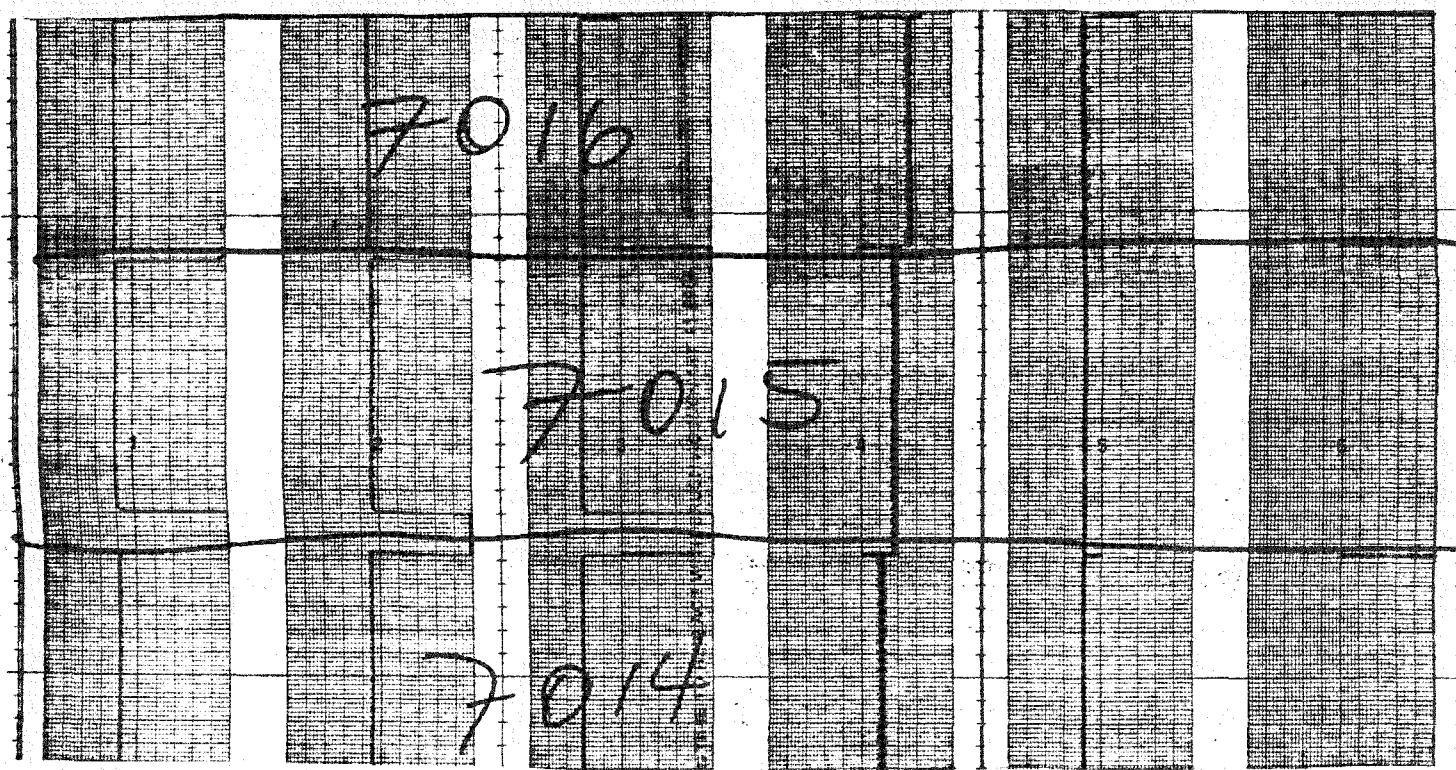
F5
DTT Momentum
Flux

LOFT Gamma Densitometer

KFK 2784

LTR LO-00-80-113

A4-5



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

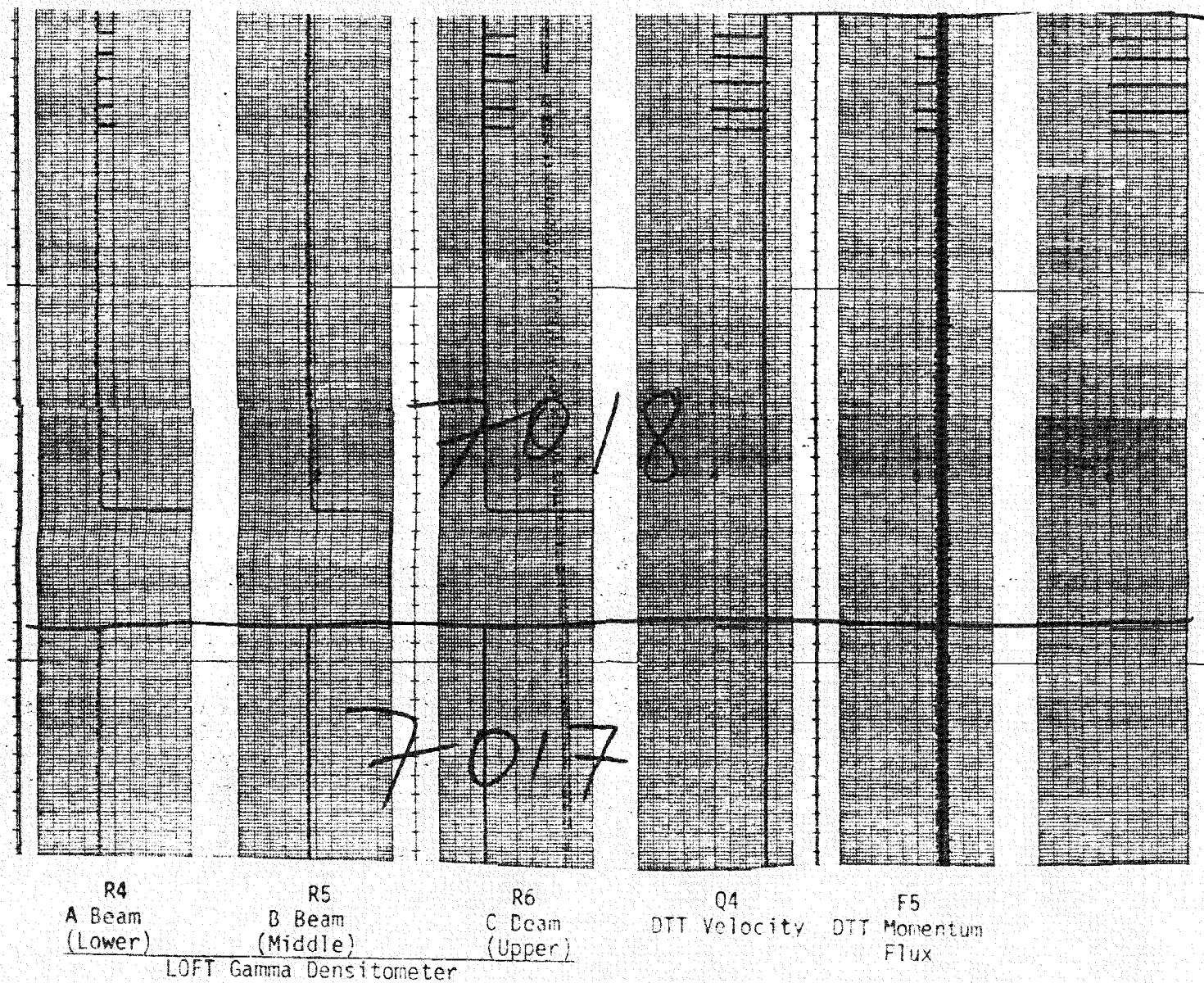
Q4
DTT Velocity

F5
DTT Momentum
Flux

LOFT Gamma Densitometer

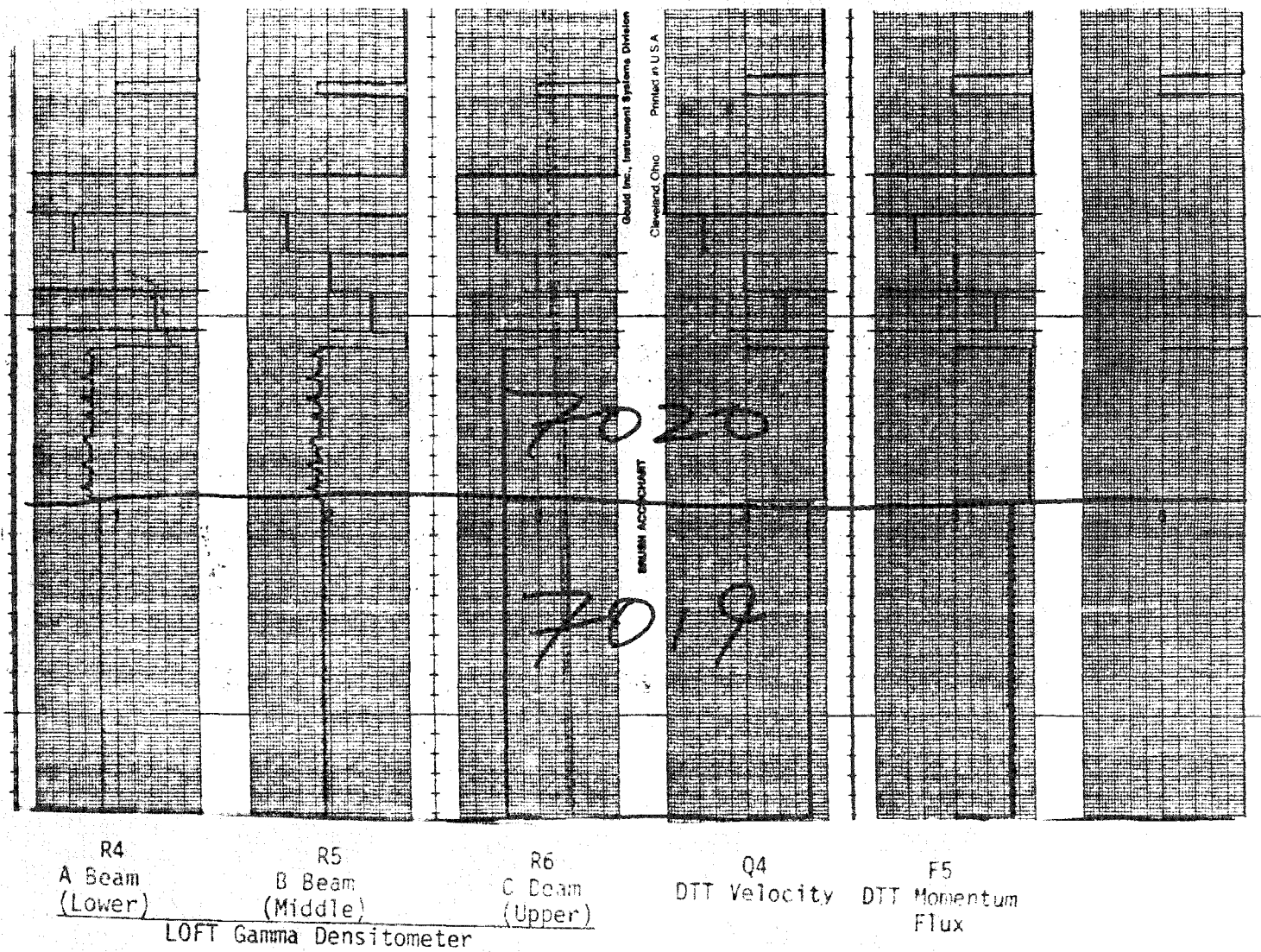
LTR LO-00-80-113

A4-6



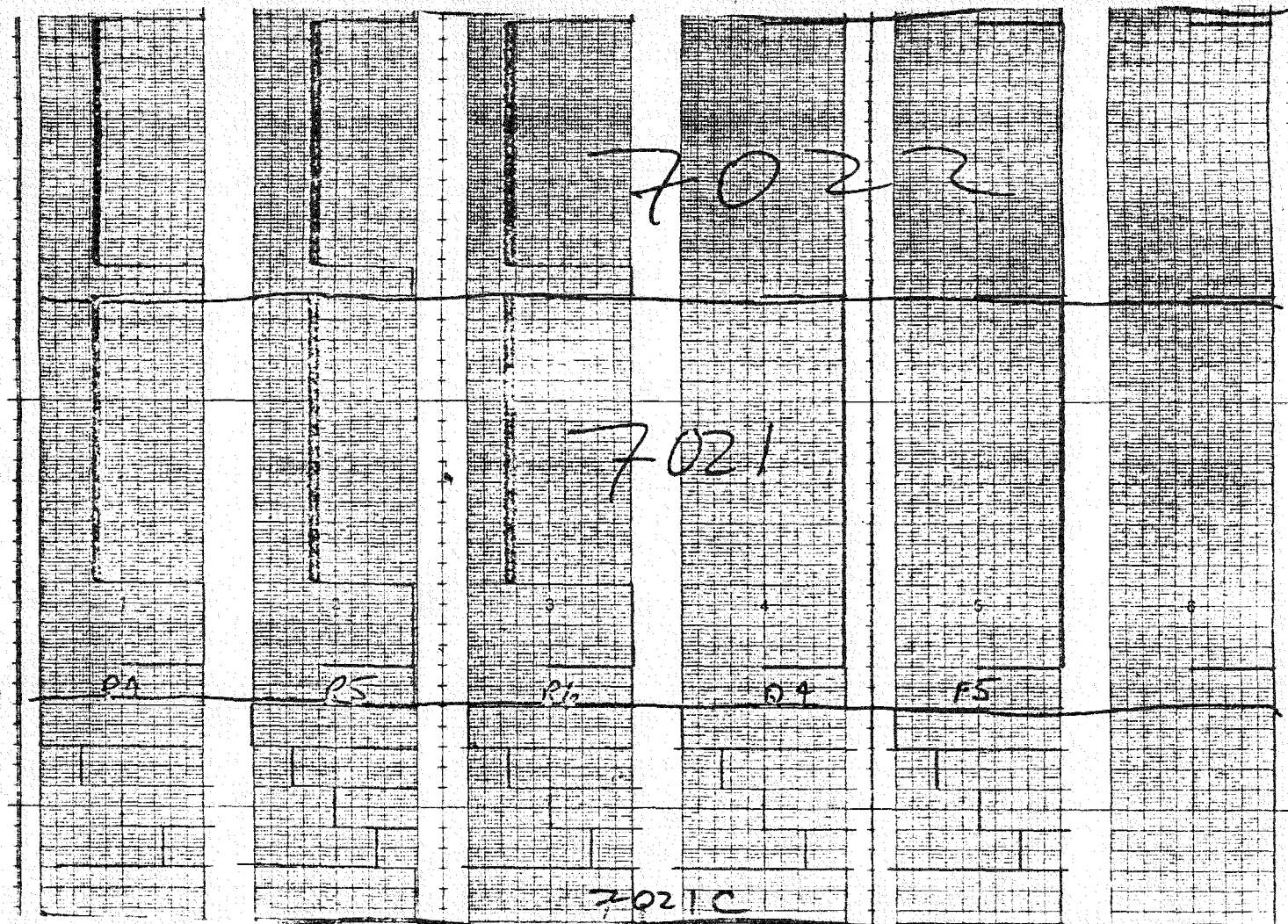
LTR L0-00-80-113
KFK 2784

A4-7



KFK 2157
LTR LO-00-80-113

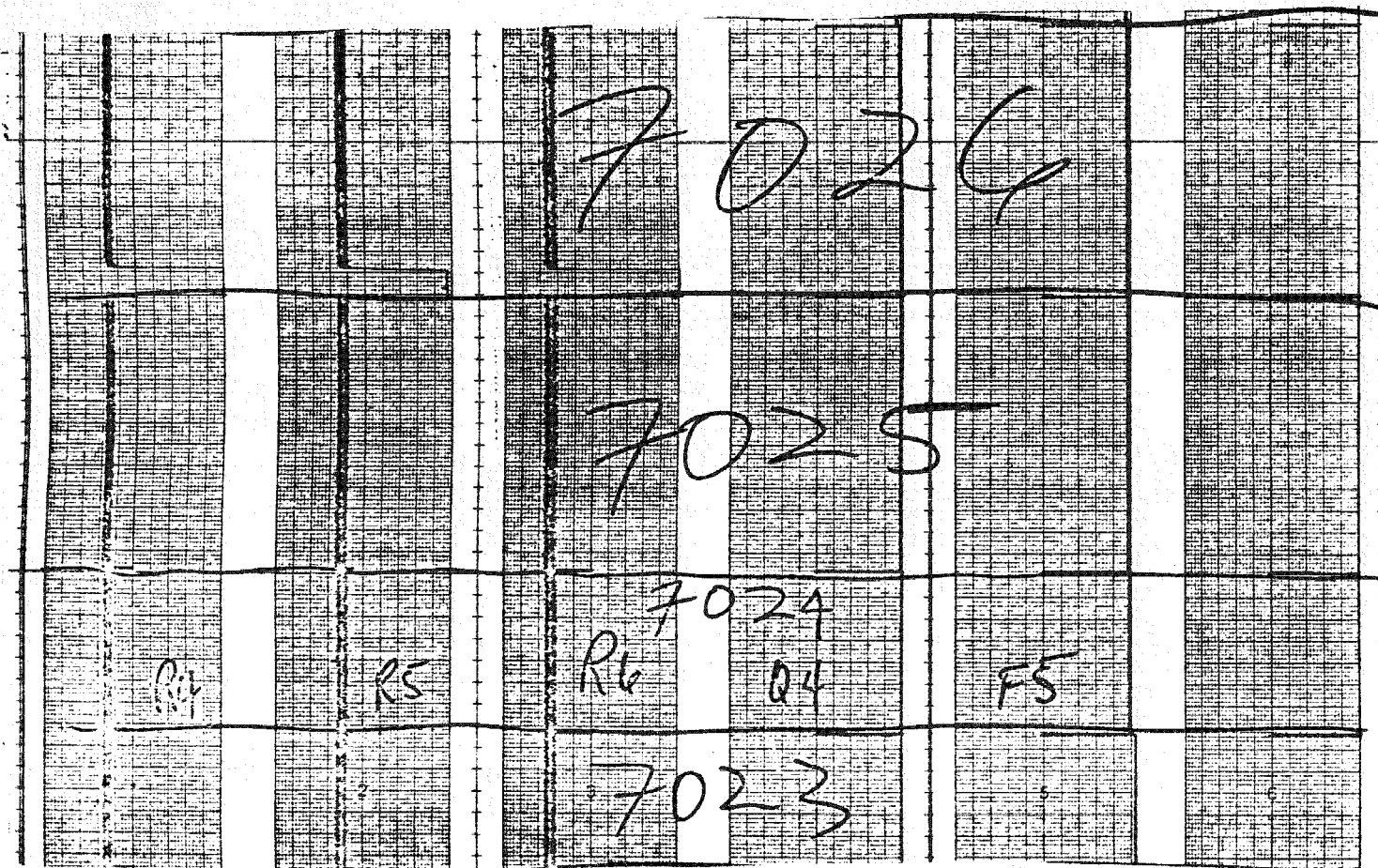
A4-8



LOFT Gamma Densitometer

LTR LO-00-80-113
KFK 2724

A4-9



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

Q4
DTT Velocity

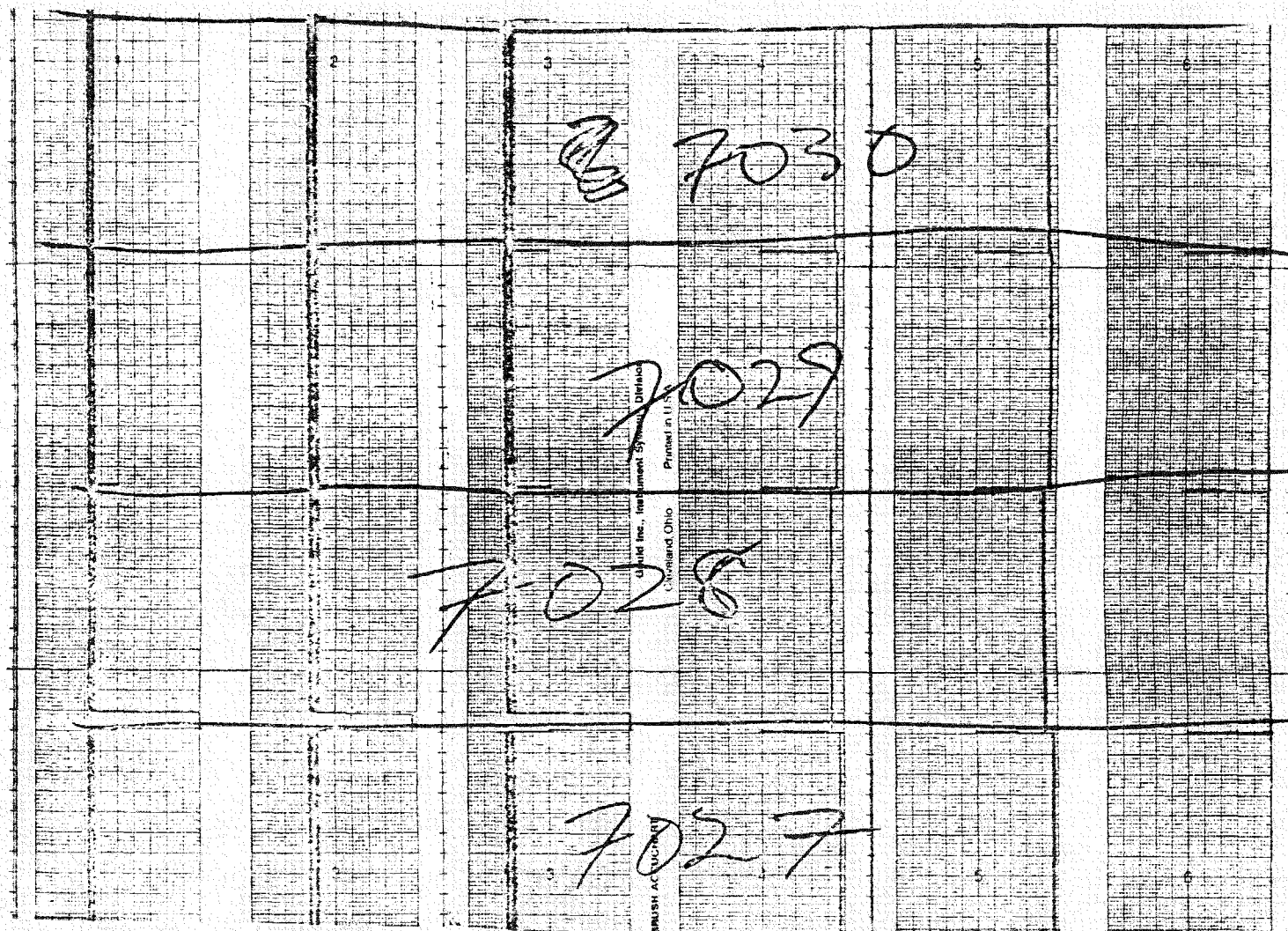
F5
DTT Momentum
Flux

LOFT Gamma Densitometer

KH 3114

LTR LO-00-80-113

A4-10



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

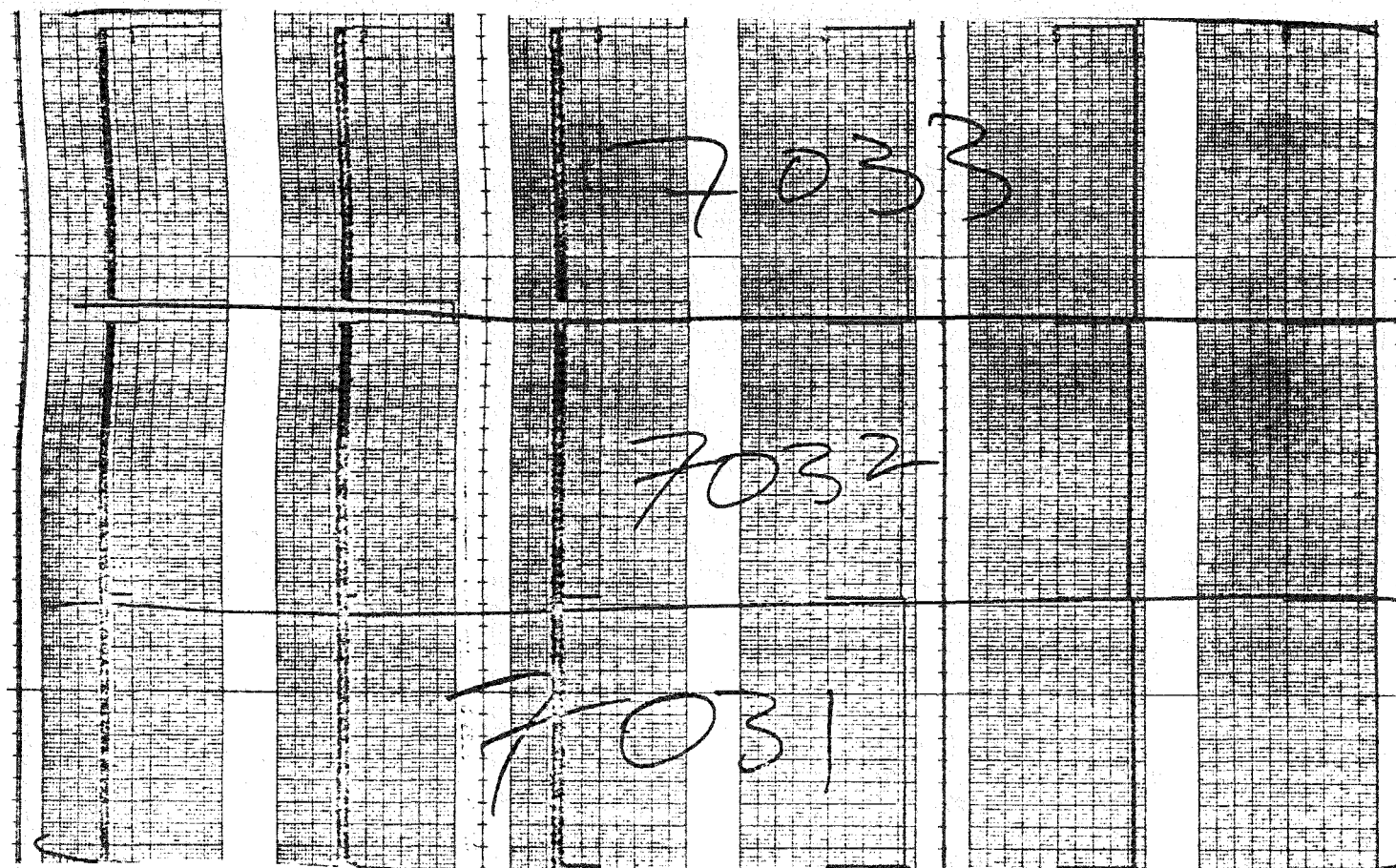
Q4
DTT Velocity

F5
DTT Momentum
Flux

LOFT Gamma Densitometer

LTR LO-00-80-113
KFK 2724

REV 2-77



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

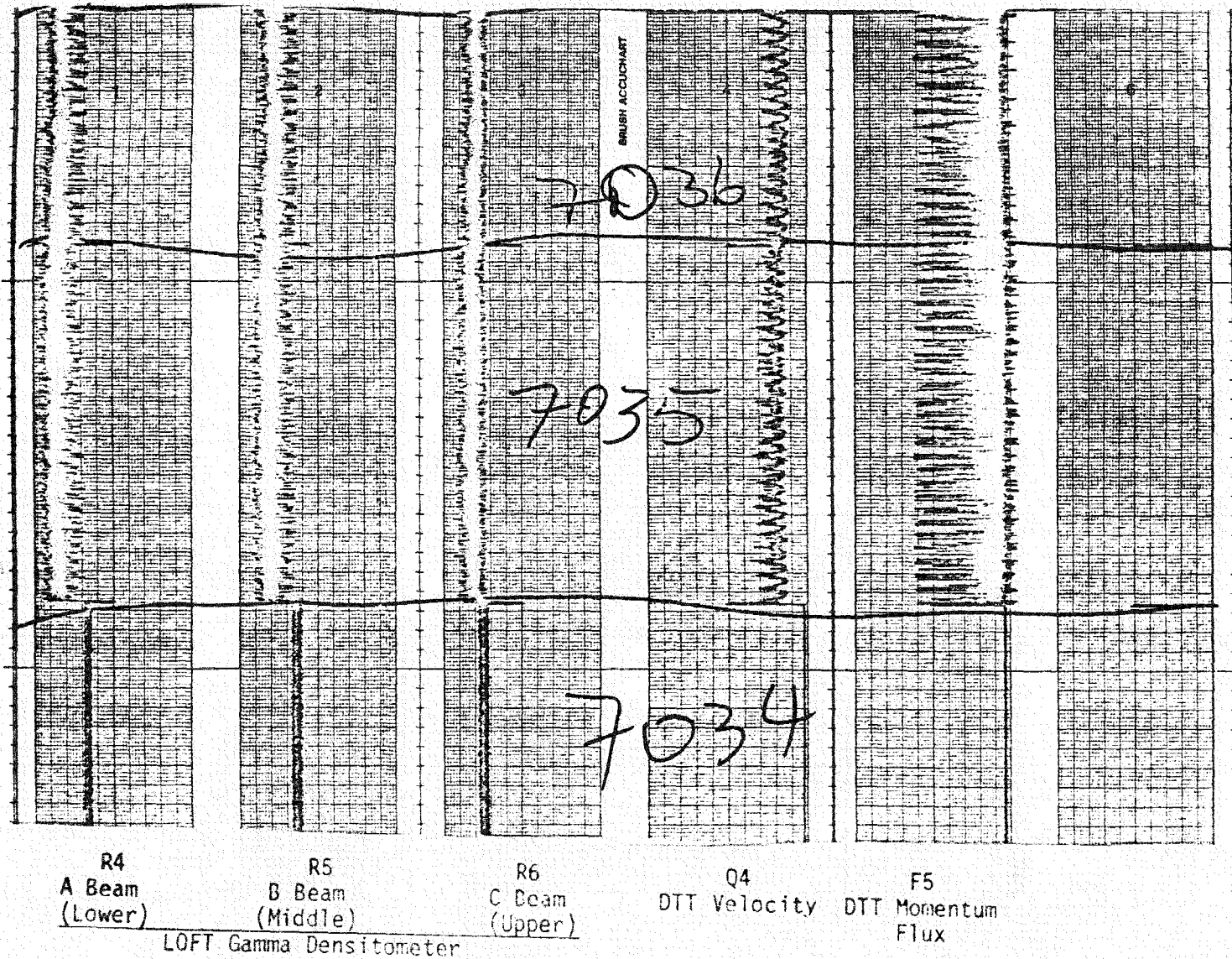
C4
DTT Velocity

F5
DTT Momentum
Flux

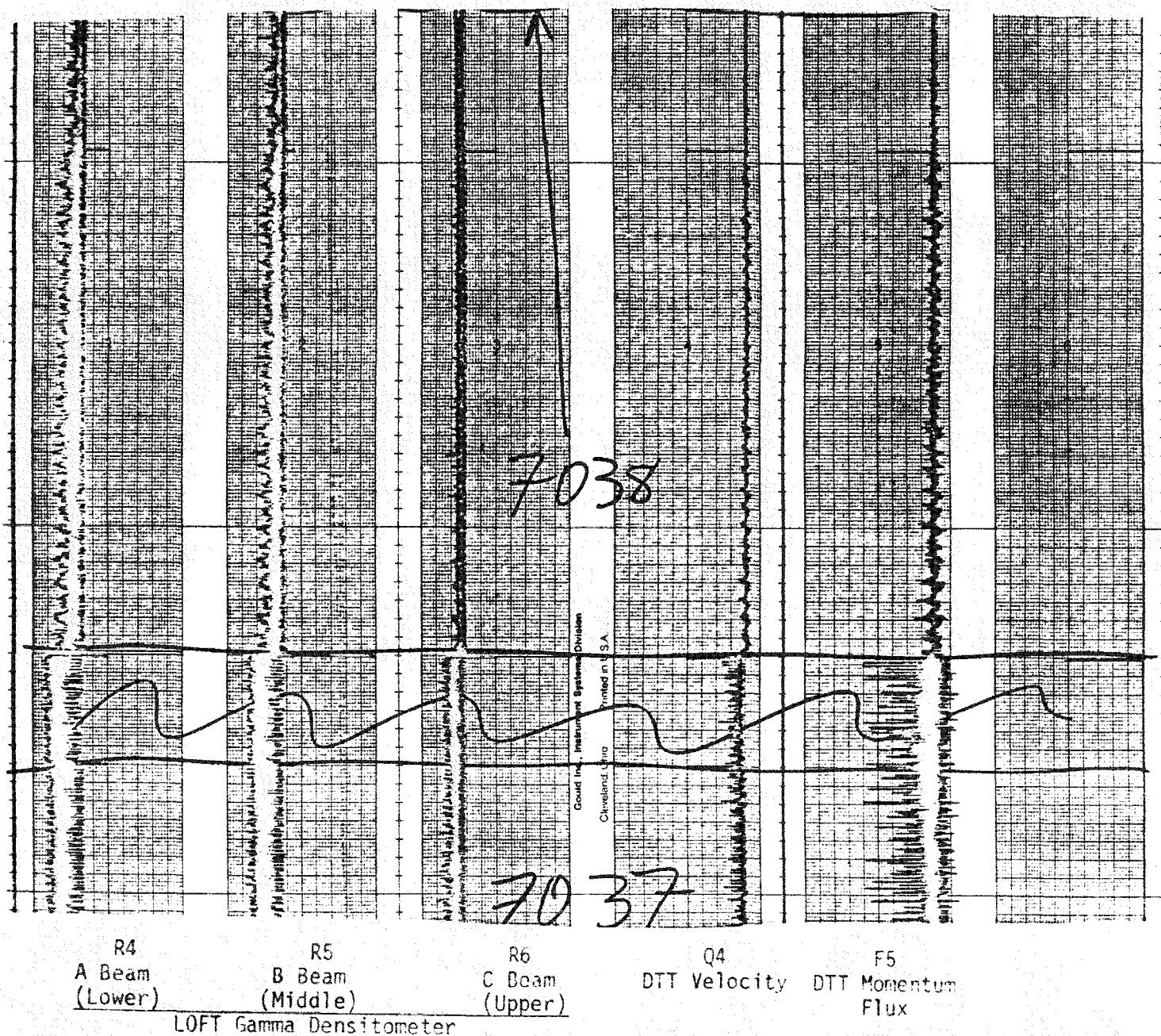
LOFT Gamma Densitometer

LTR LO-00-80-113

KFK 2784

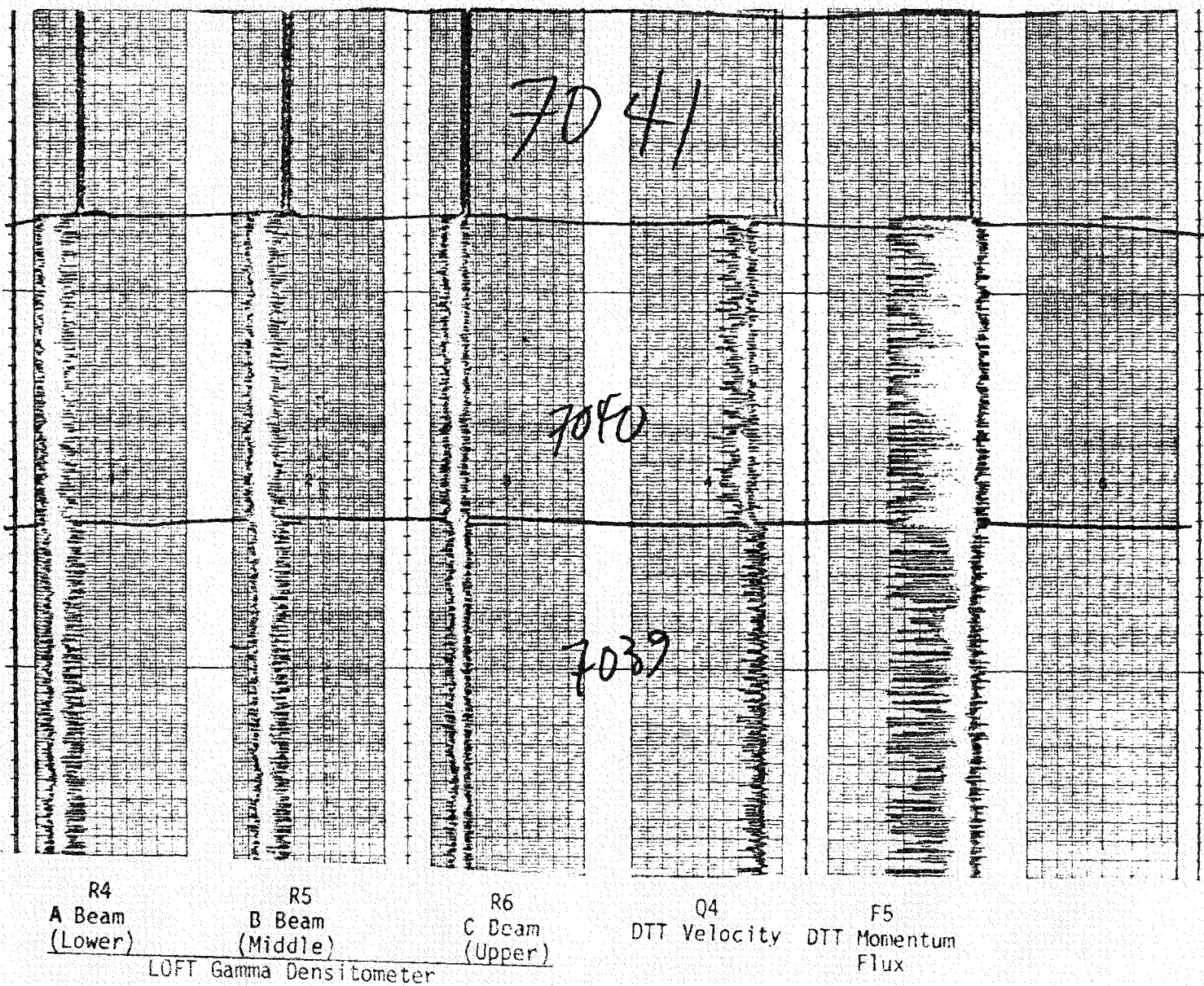


A4-13



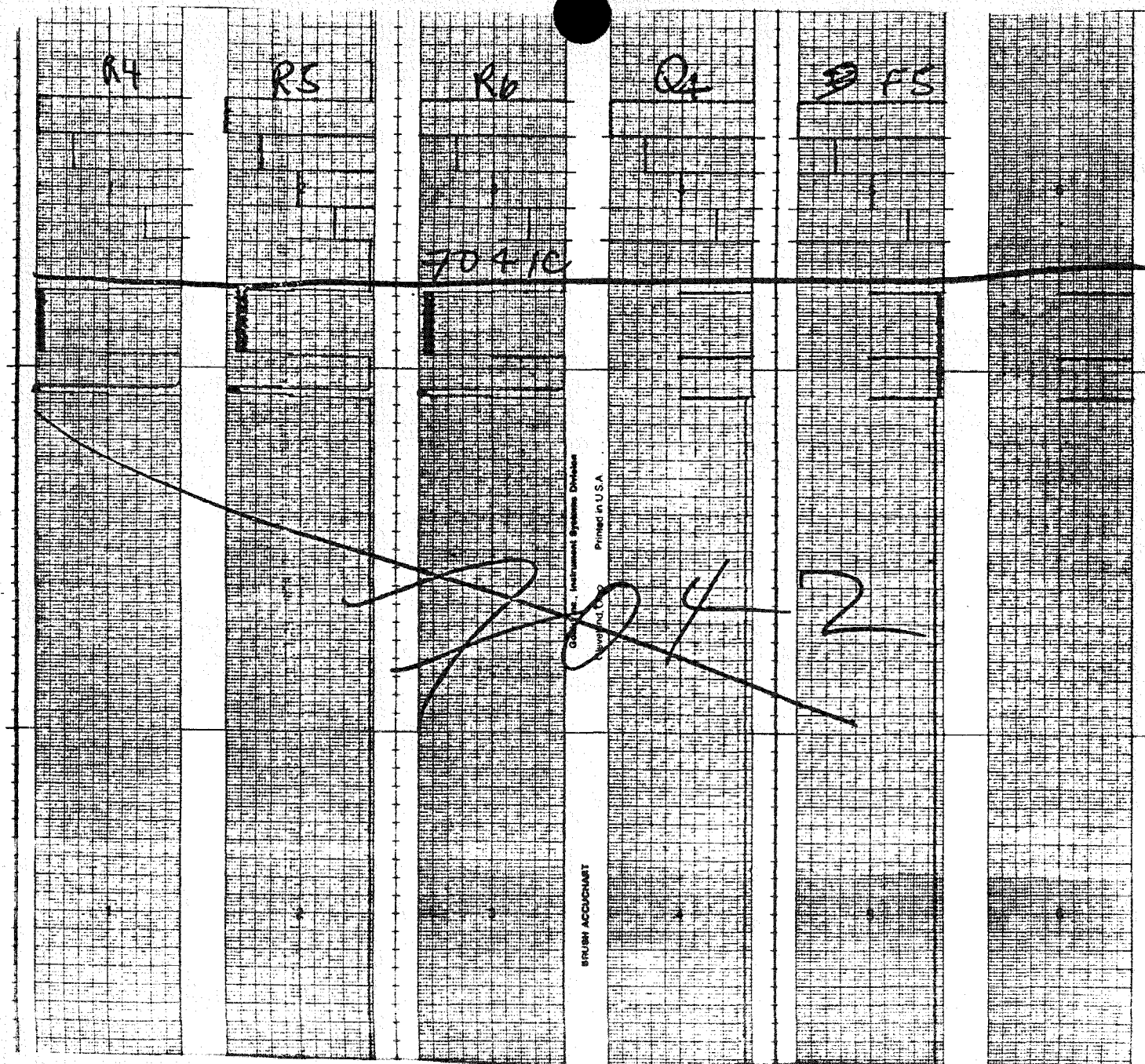
LTR LO-00-80-113
VTR 5737

LTR LO-00-80-113



AA-14

A4-15



R4
A Beam
(Lower)

R5
B Beam
(Middle)

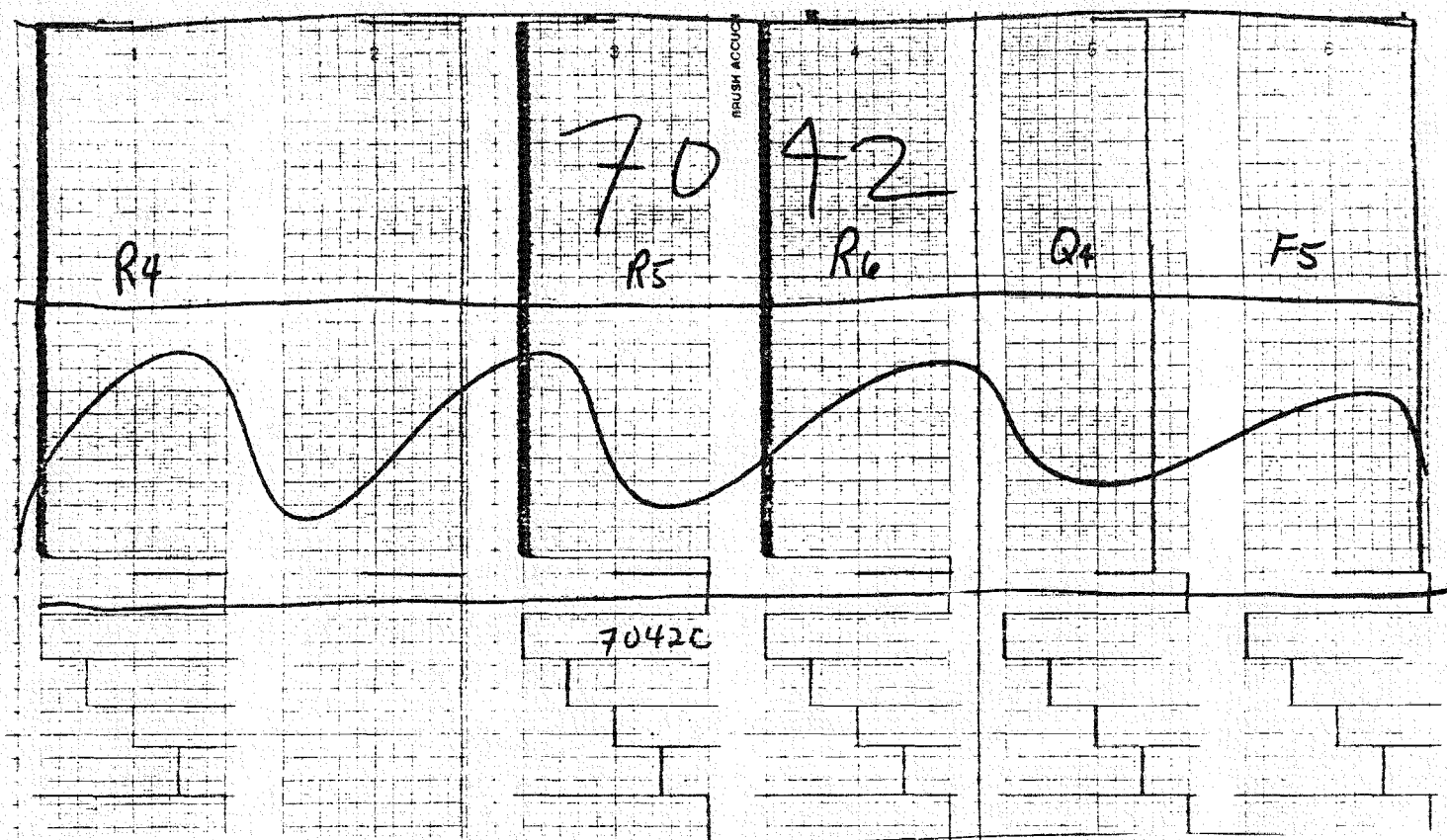
R6
C Beam
(Upper)

Q4
DTT Velocity

F5
DTT Momentum
Flux

LTR LO-00-80-113
KfA 2784

A4-16



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

Q4
DTT Velocity

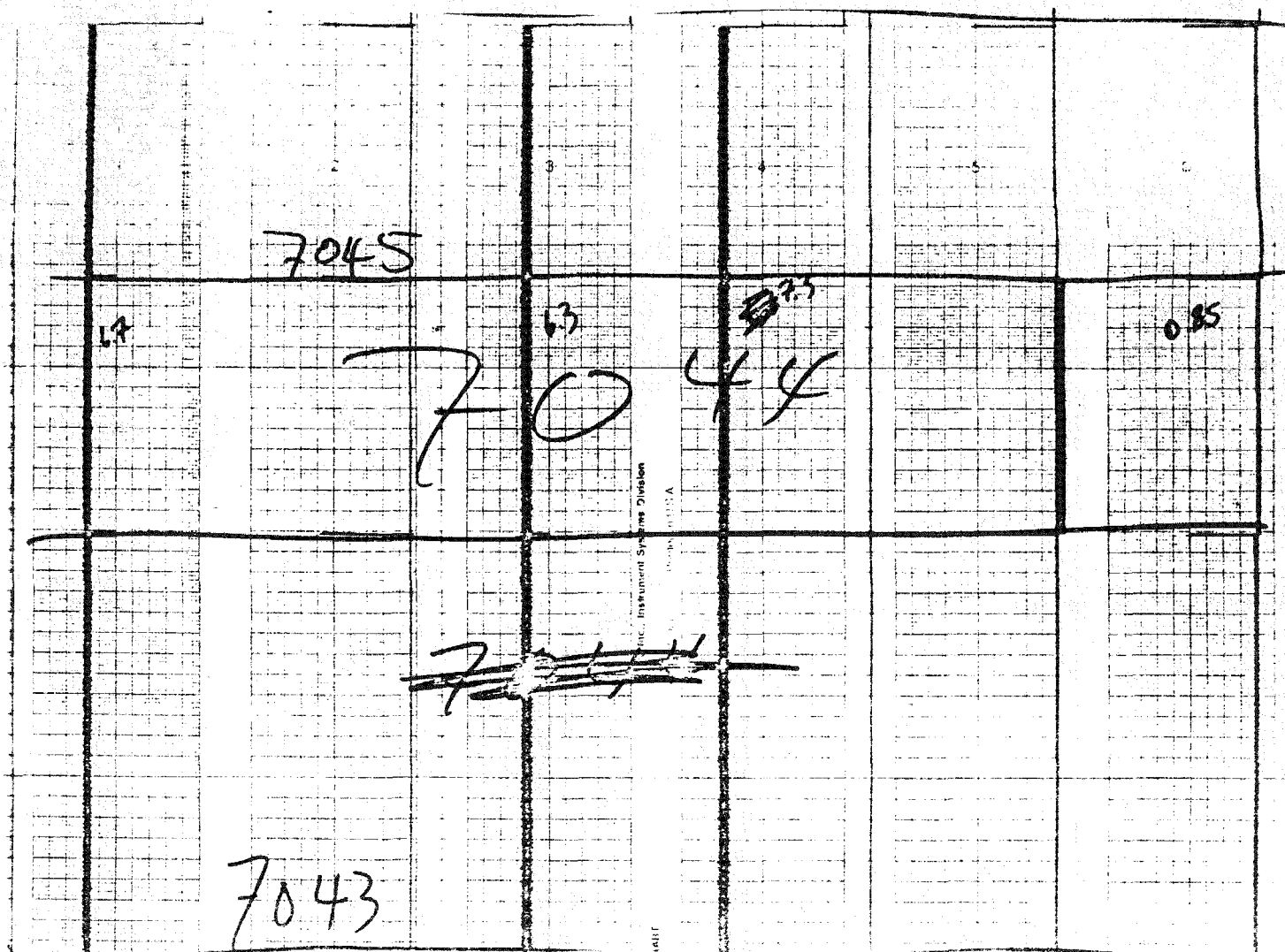
F5
DTT Momentum
Flux

LOFT Gamma Densitometer

REF 2761

LTR LO-00-80-113

A4-17



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

Q4
DTT Velocity

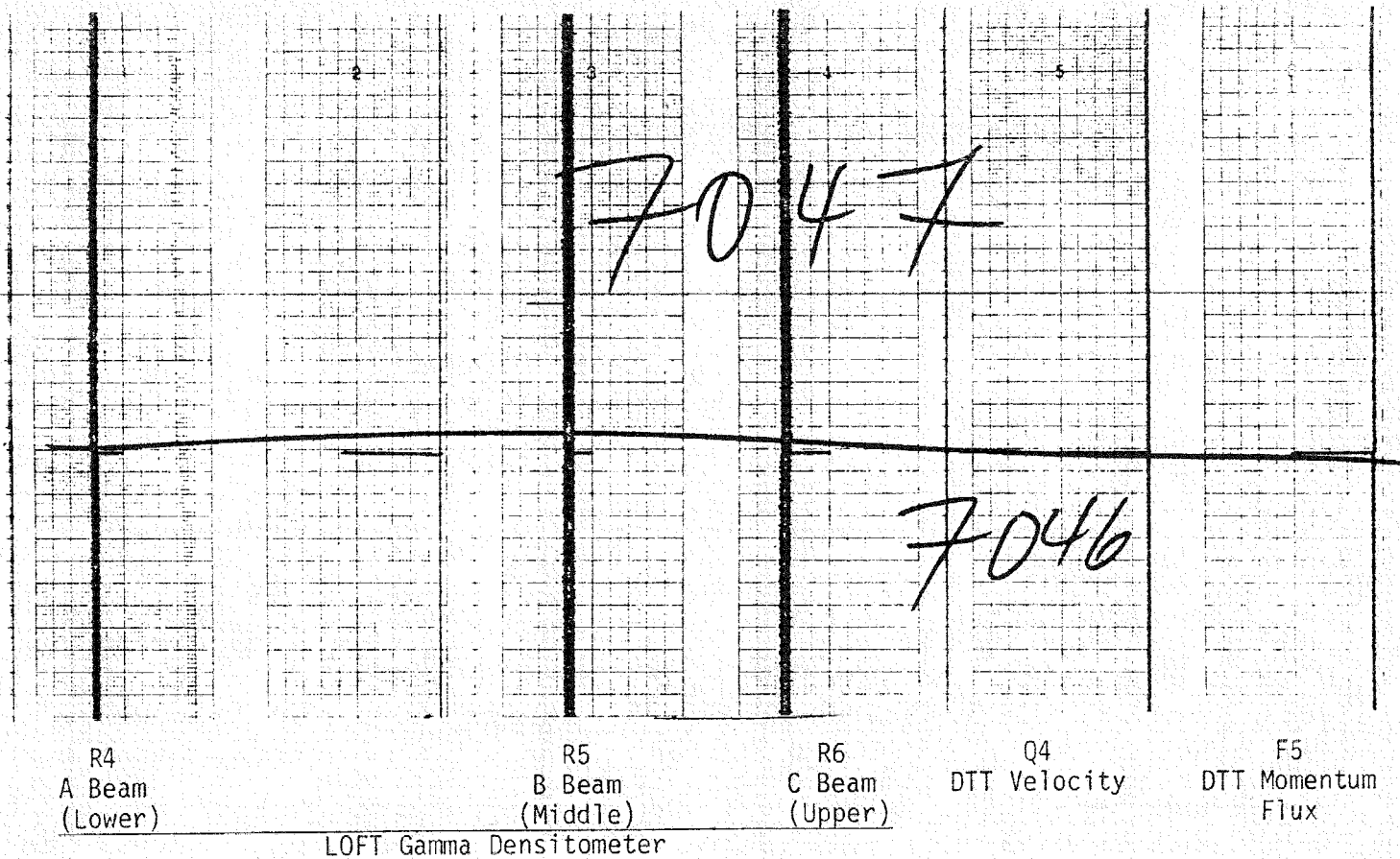
F5
DTT Momentum
Flux

LOFT Gamma Densitometer

VFK 2784

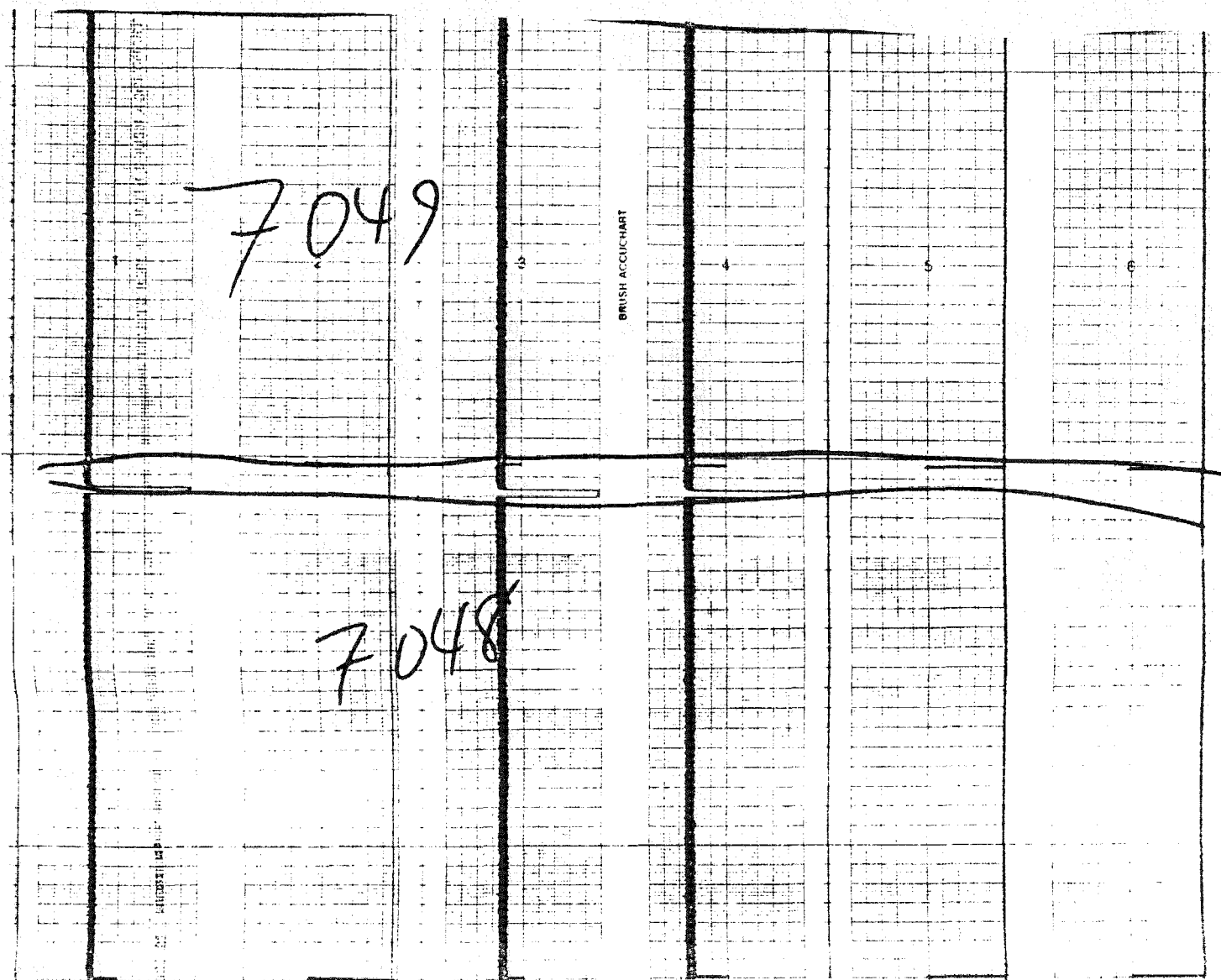
LTR LO-00-80-113

A4-18



LTR LO-00-80-113
KFK 2784

A4-19



R4
A Beam
(Lower)

R5
B Beam
(Middle)
LOFT Gamma Densitometer

R6
C Beam
(Upper)

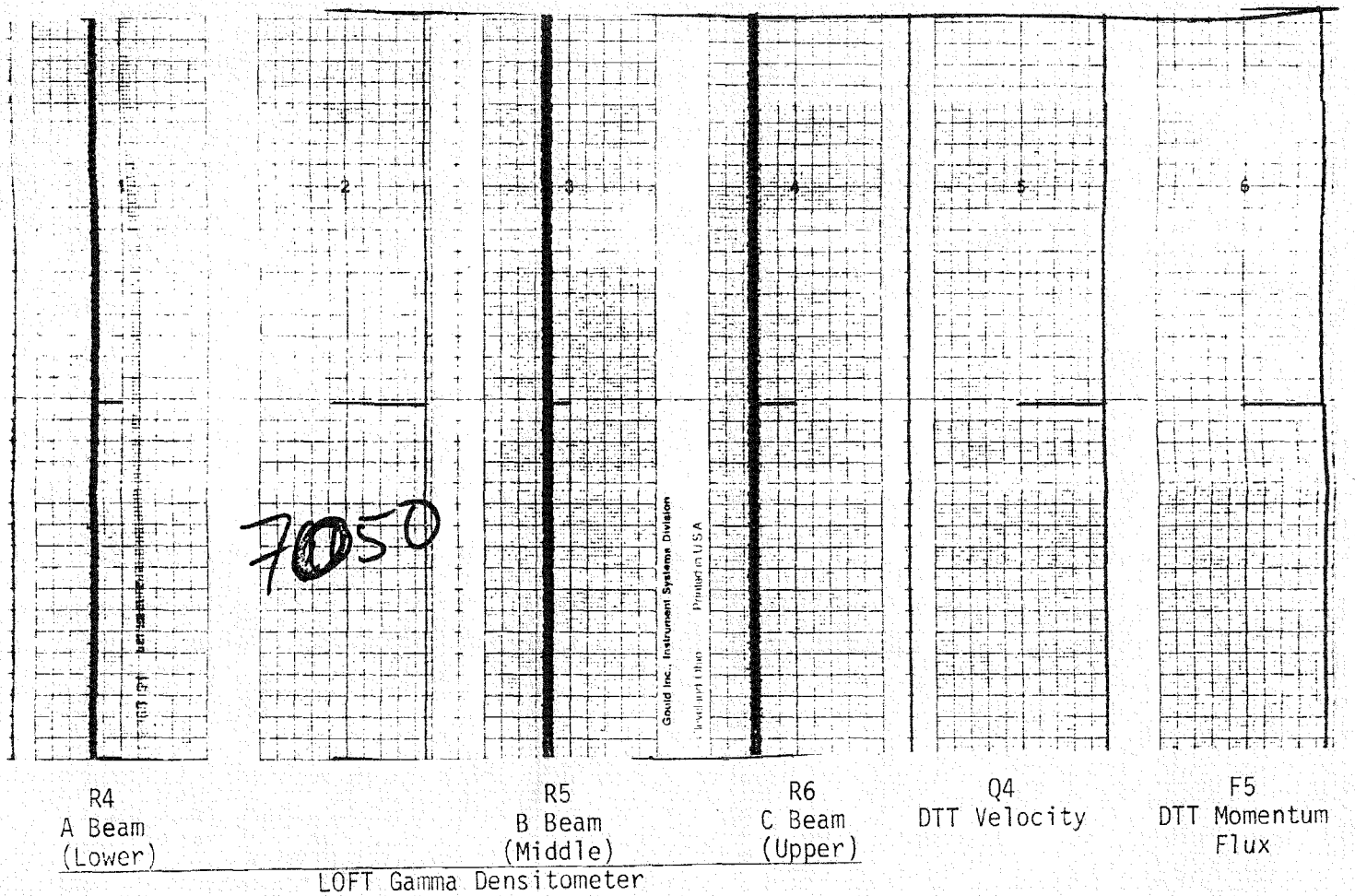
Q4
DTT Velocity

F5
DTT Momentum
Flux

MTK 2704

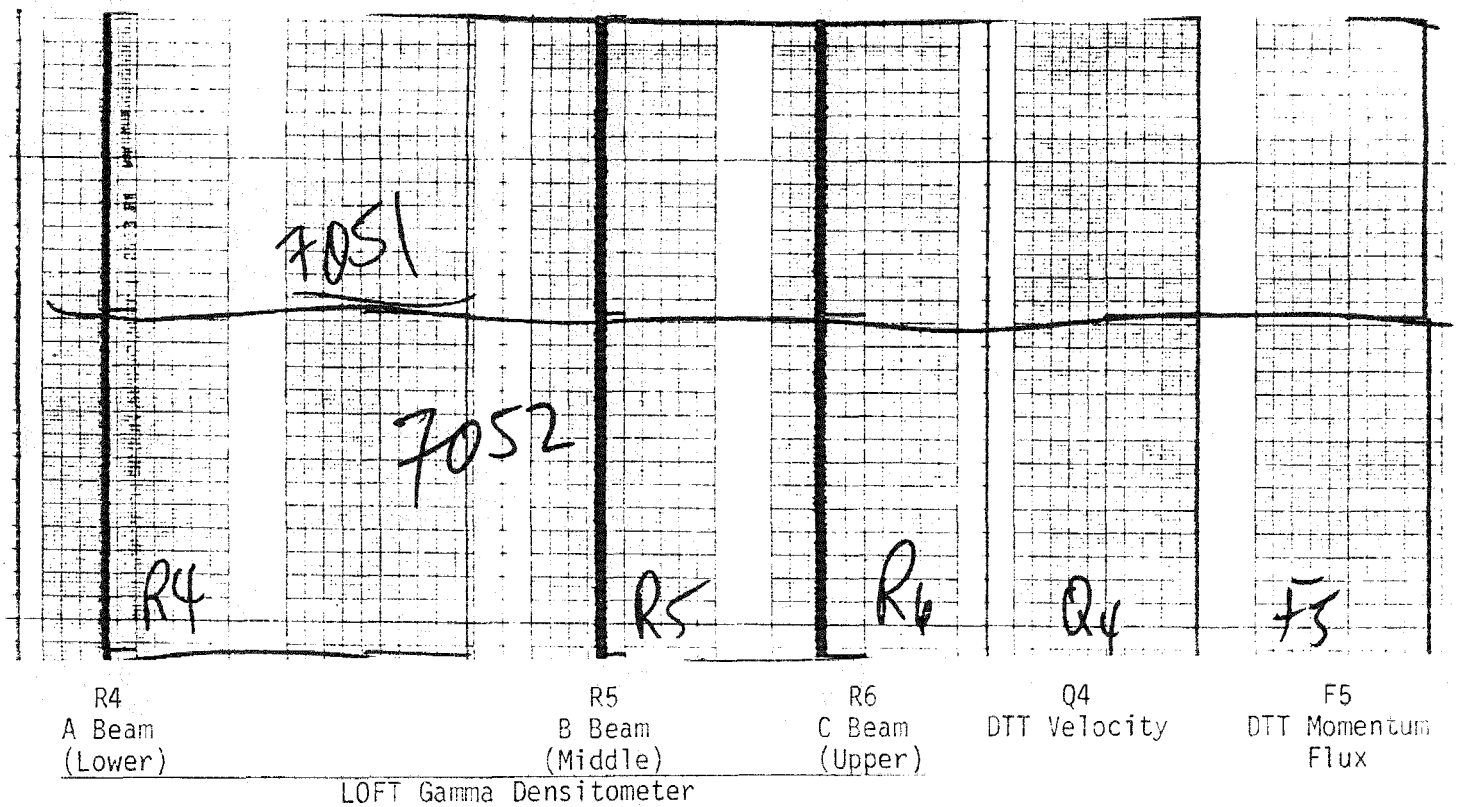
LTR LO-00-80-113

A4-20



LTR LO-00-80-113
KFK 2724

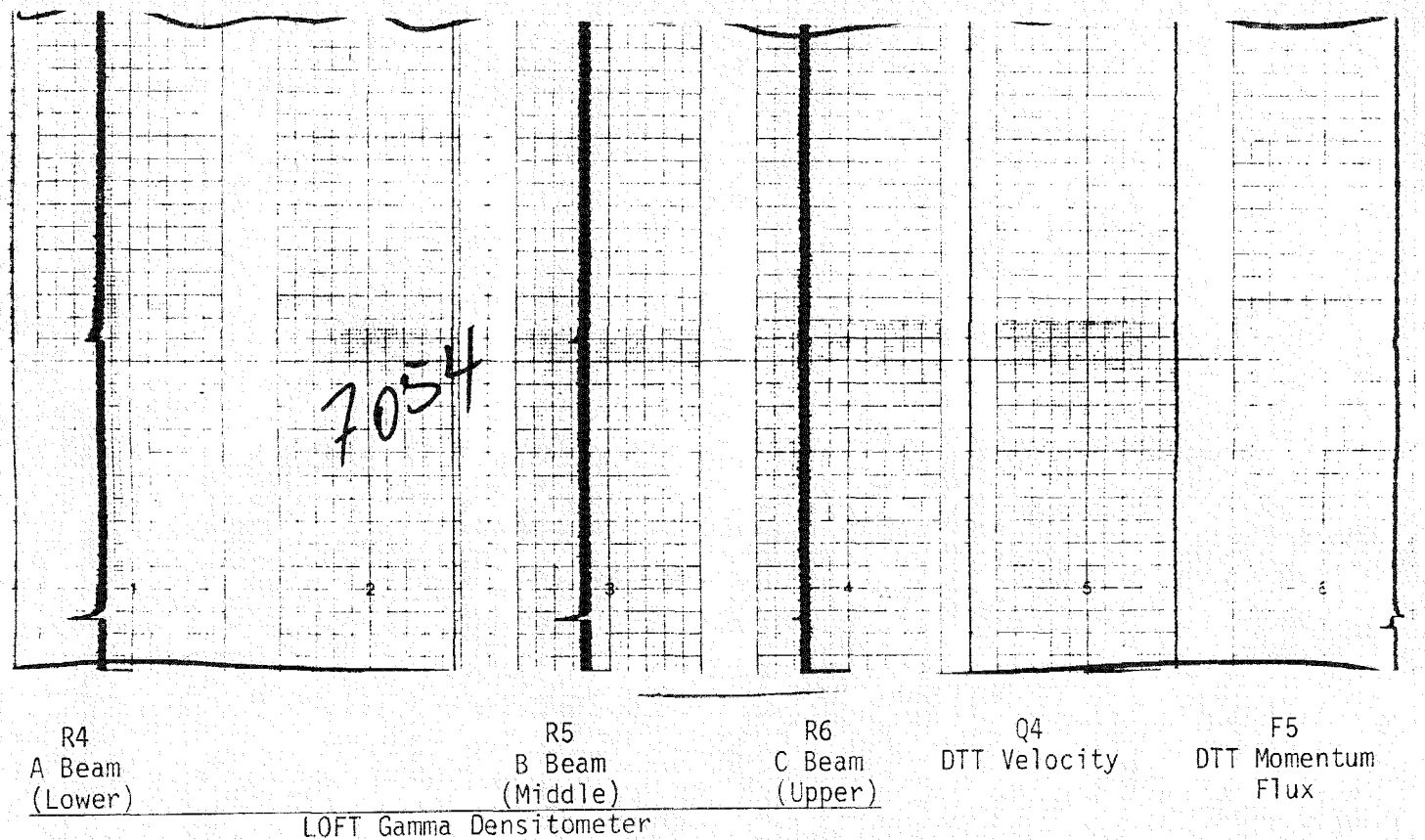
A4-21



KFK 2704

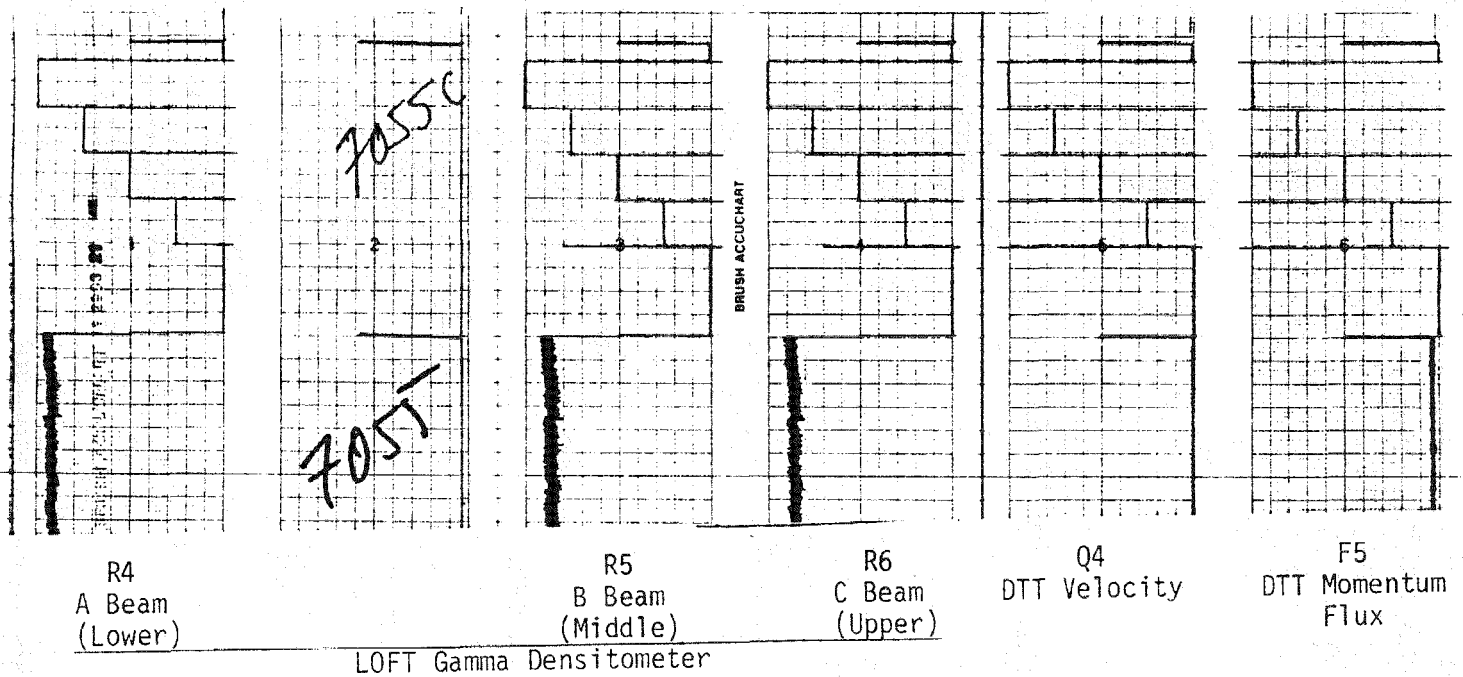
LTR LO-00-80-113

A4-22



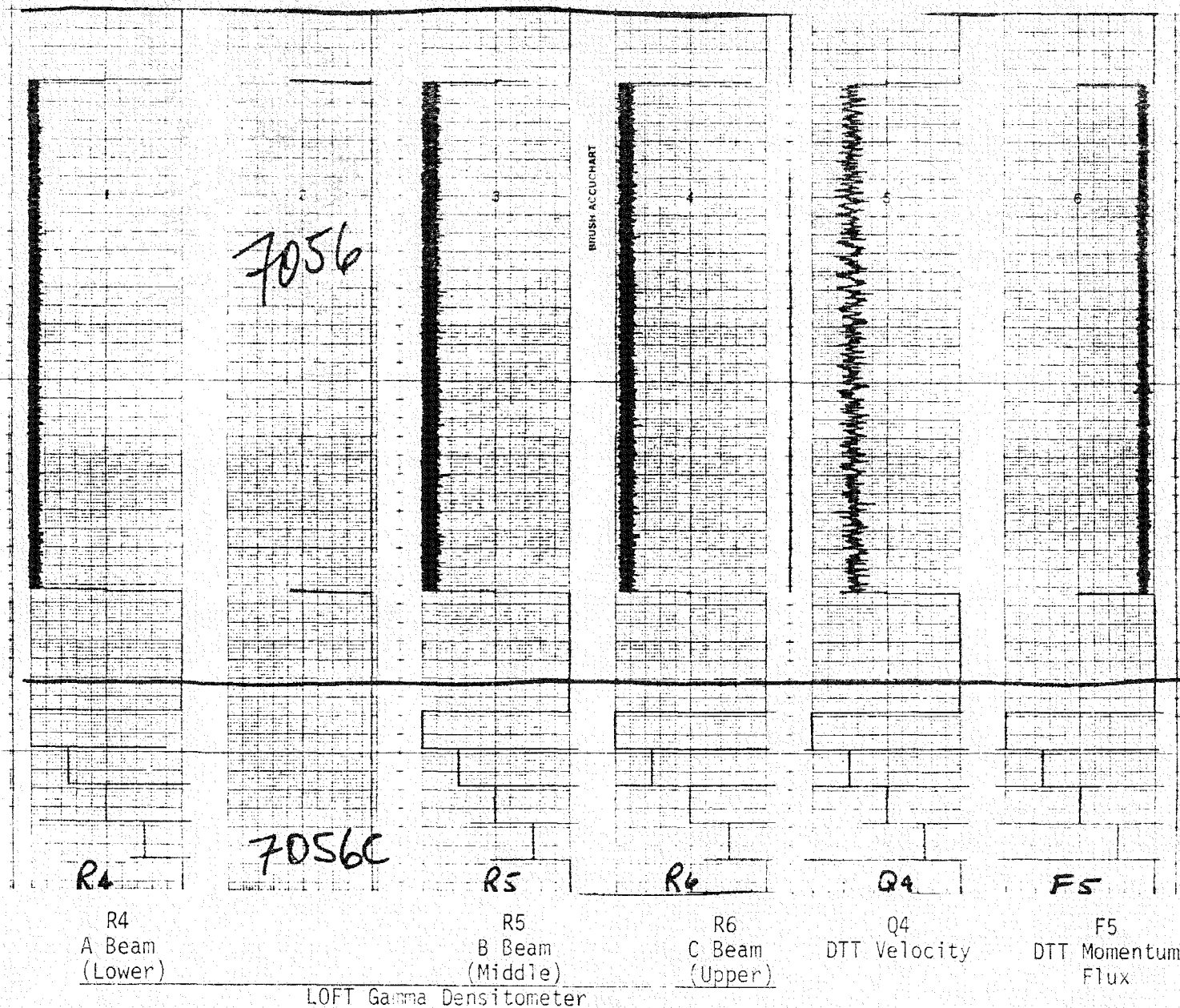
LTR L0-00-80-113
KFK 2784

A4-23



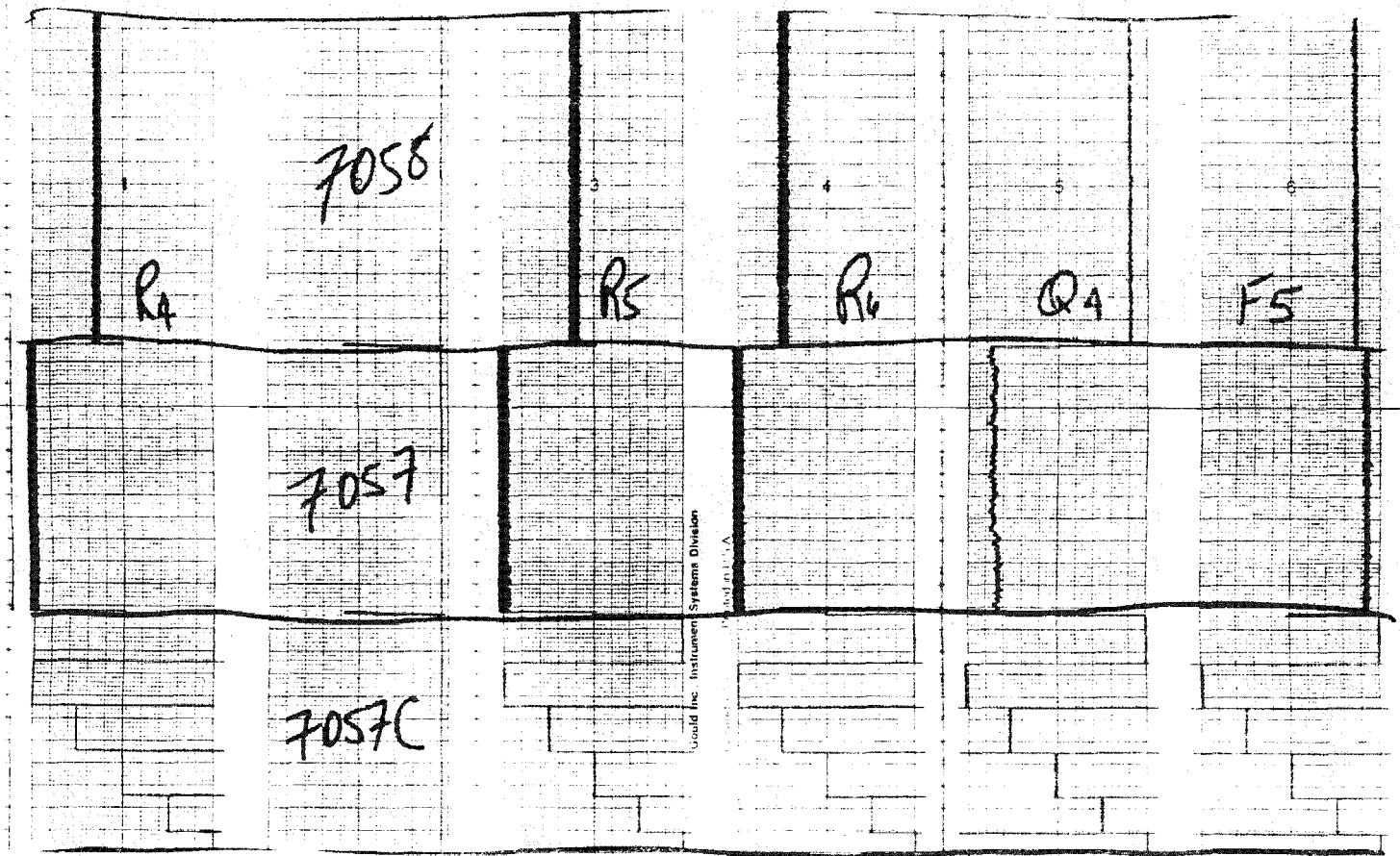
LTR LO-00-80-113
KFK 228

A4-24



LTR LO-00-80-113
KFK 2784

A4-25



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

Q4
DTT Velocity

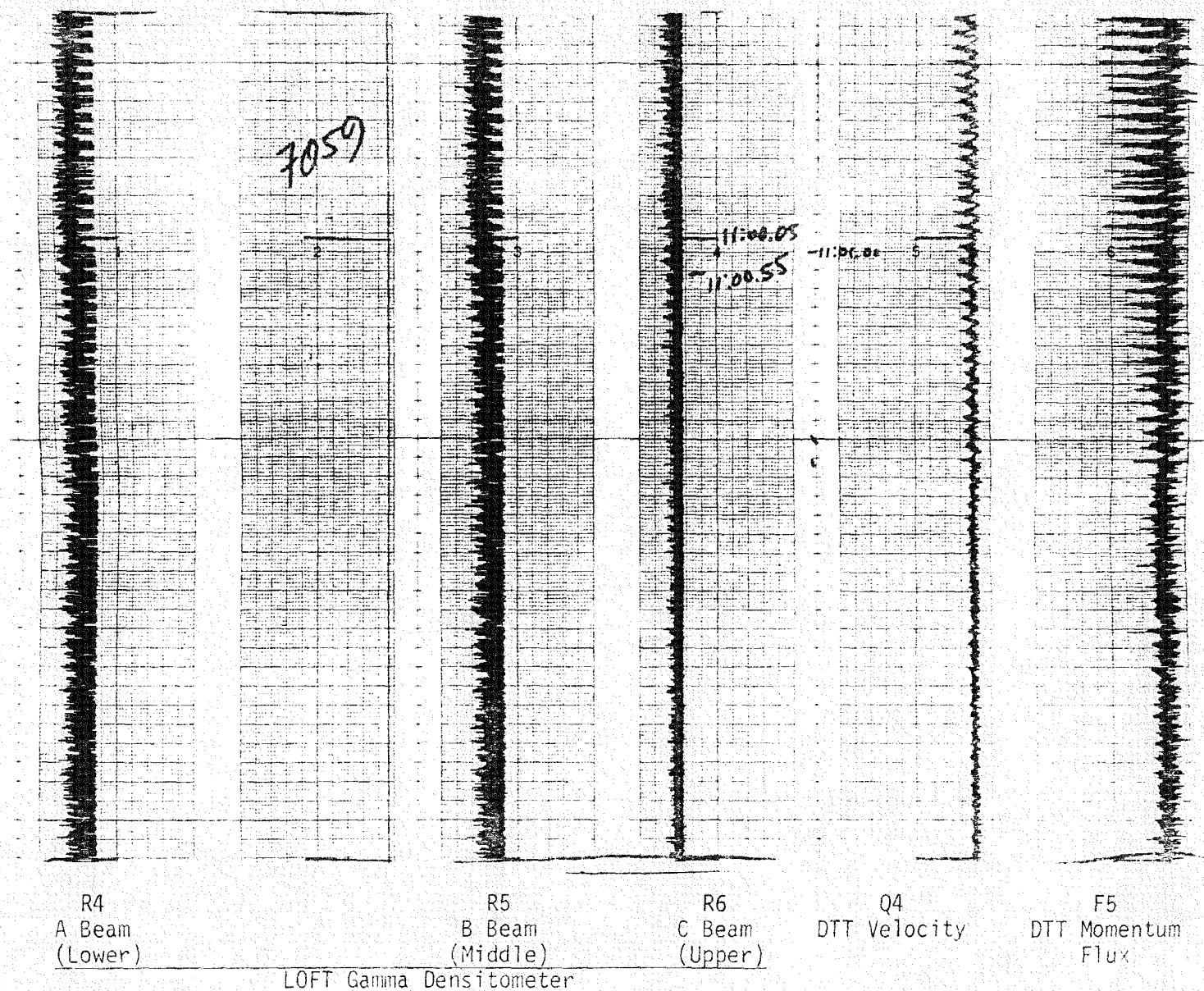
F5
DTT Momentum
Flux

LOFT Gamma Densitometer

KFK 2/04

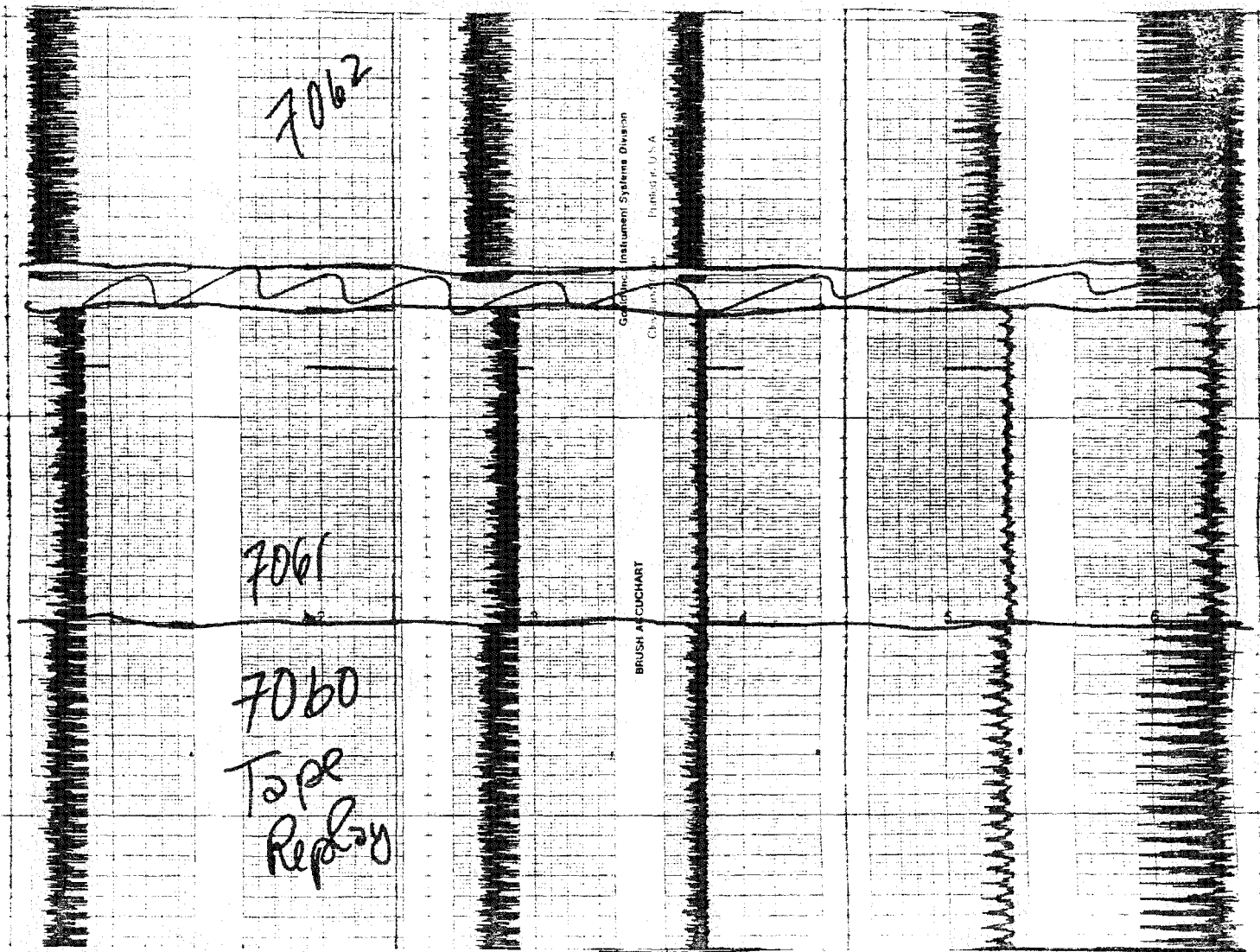
LTR LO-00-80.113

A4-26



LTR LO-00-80-113
KFK 2784

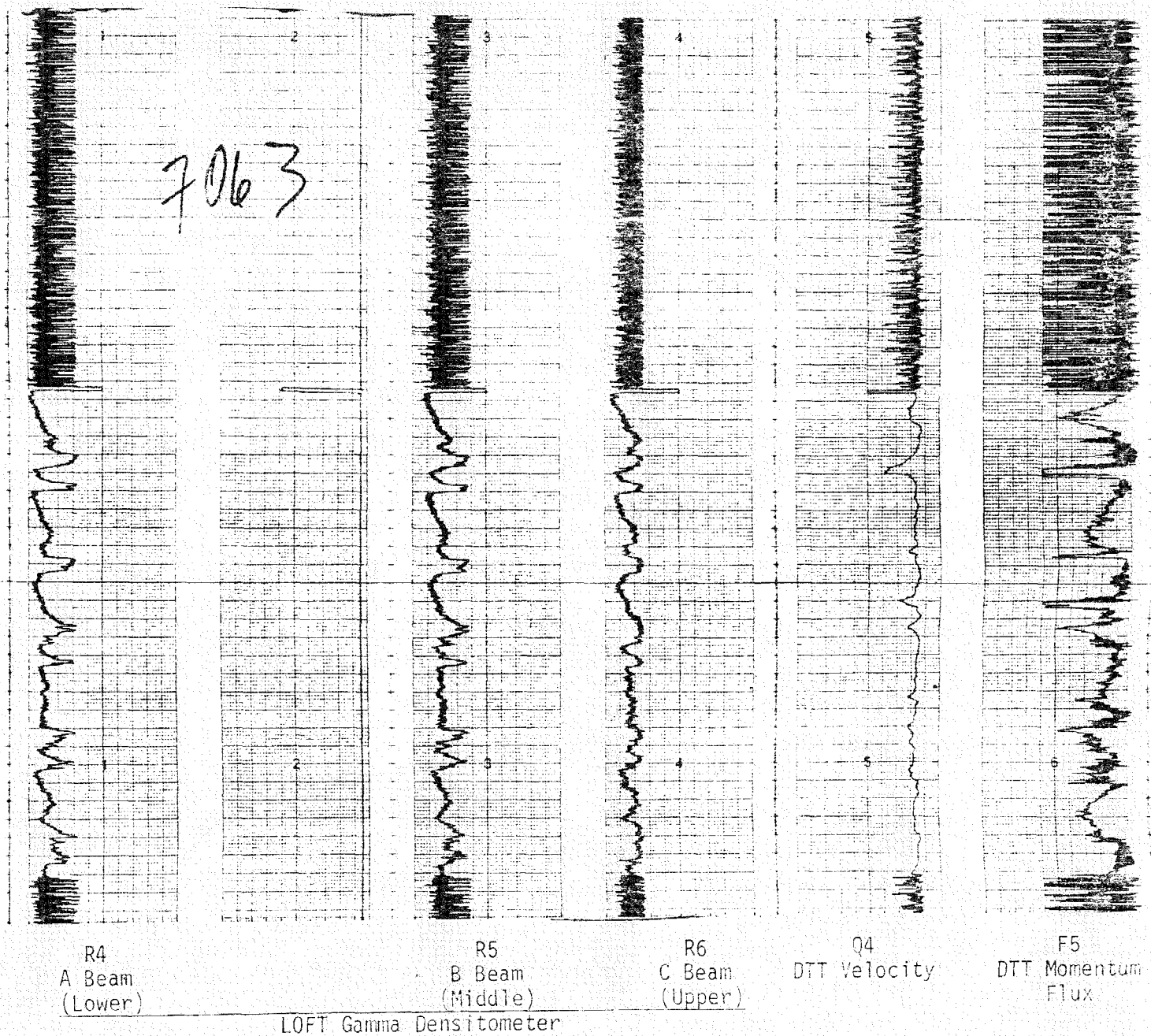
A4-27



LOFT Gamma Densitometer

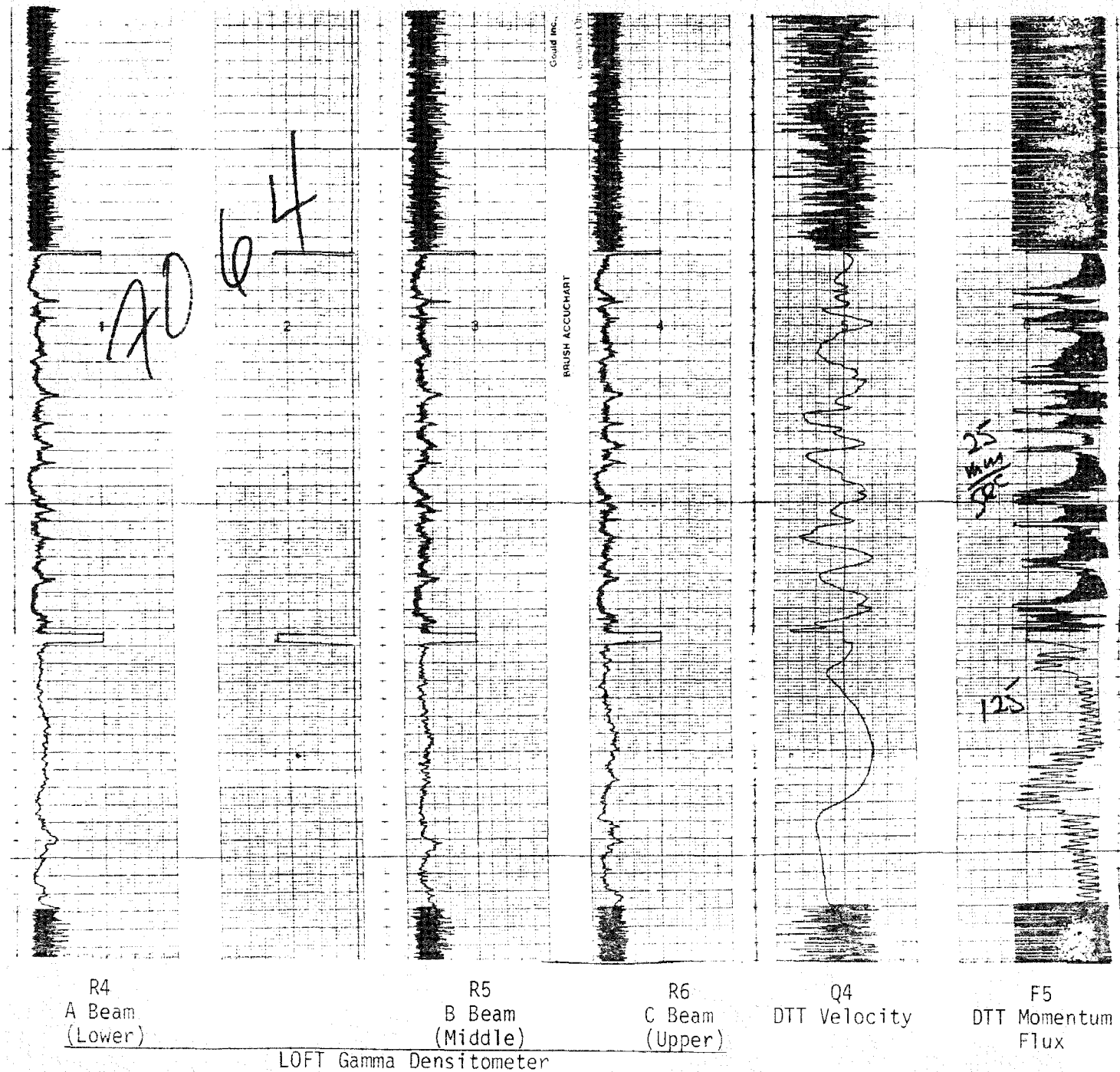
LTR 10-00-80-113

A4-28



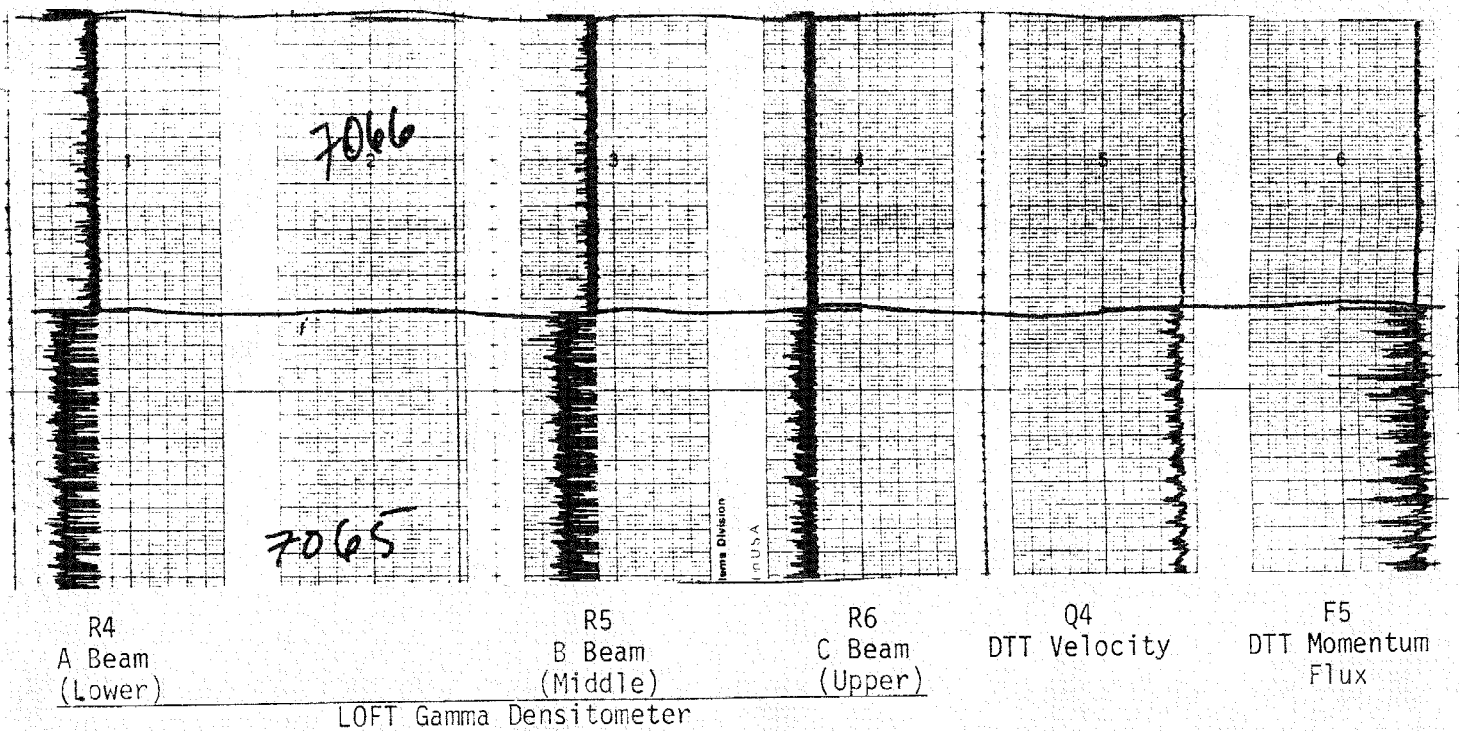
LTR L0-00-80-113
RIK 2734

A4-29



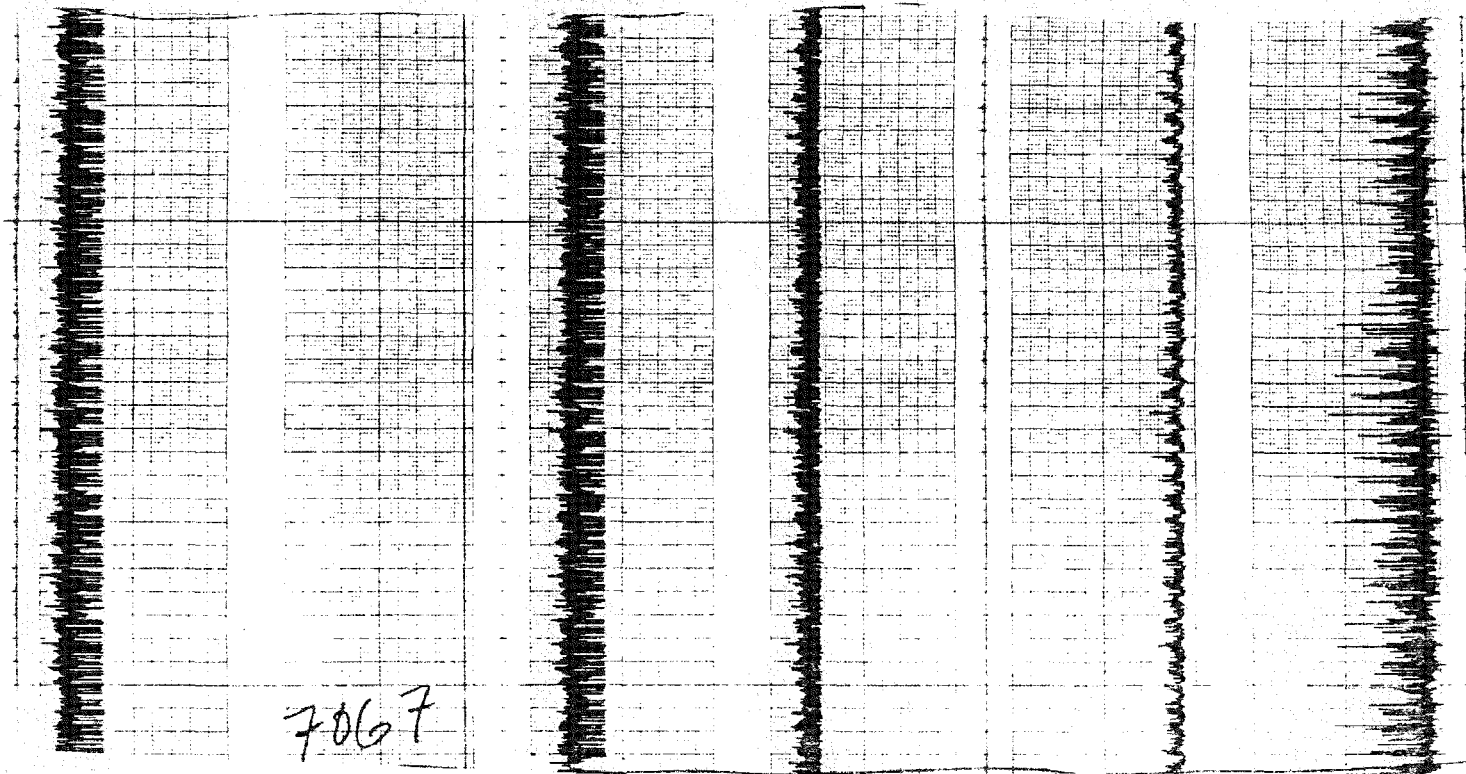
KIR 2.01
LTR 10-00-80.13

A4-30



LTR LO-00-80-113
KFK 2784

A4-31



R4
A Beam
(Lower)

R5
B Beam
(Middle)
LOFT Gamma Densitometer

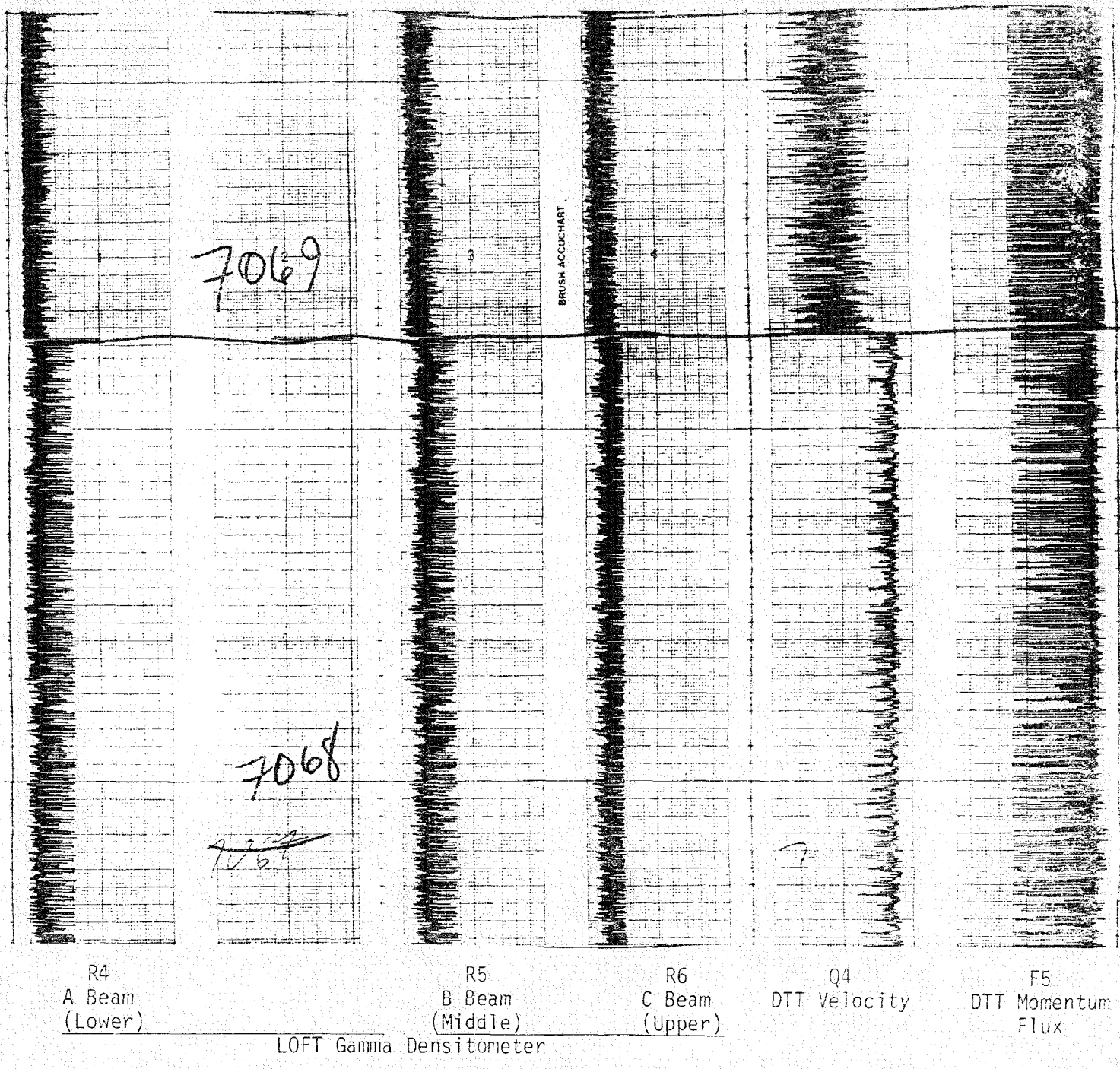
R6
C Beam
(Upper)

Q4
DTT Velocity

F5
DTT Momentum
Flux

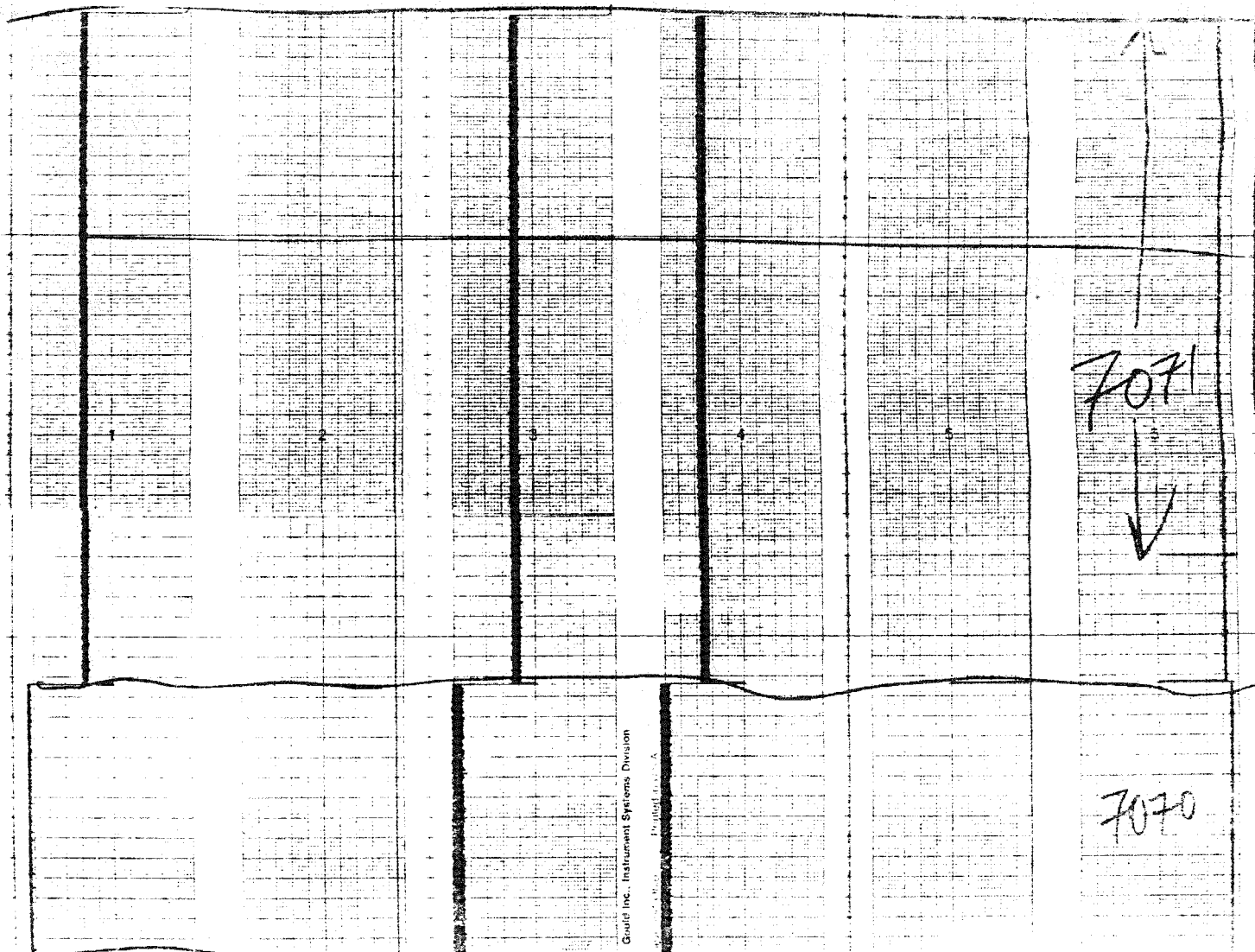
LTR L0-00-80-113

A4-32



LTR LO-00-80-113
KFK 2724

A4-33



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

Q4
DTT Velocity

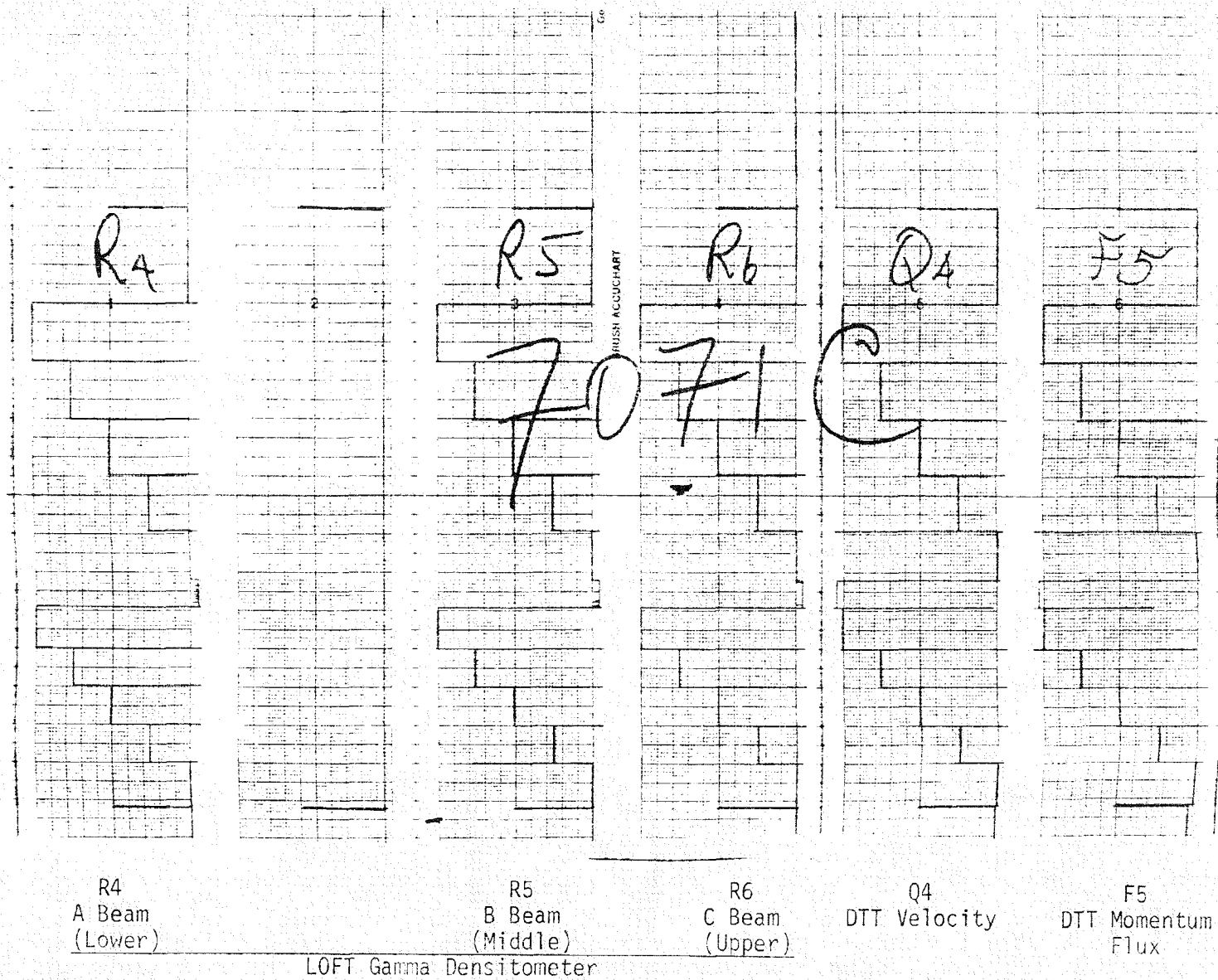
F5
DTT Momentum
Flux

LOFT Gamma Densitometer

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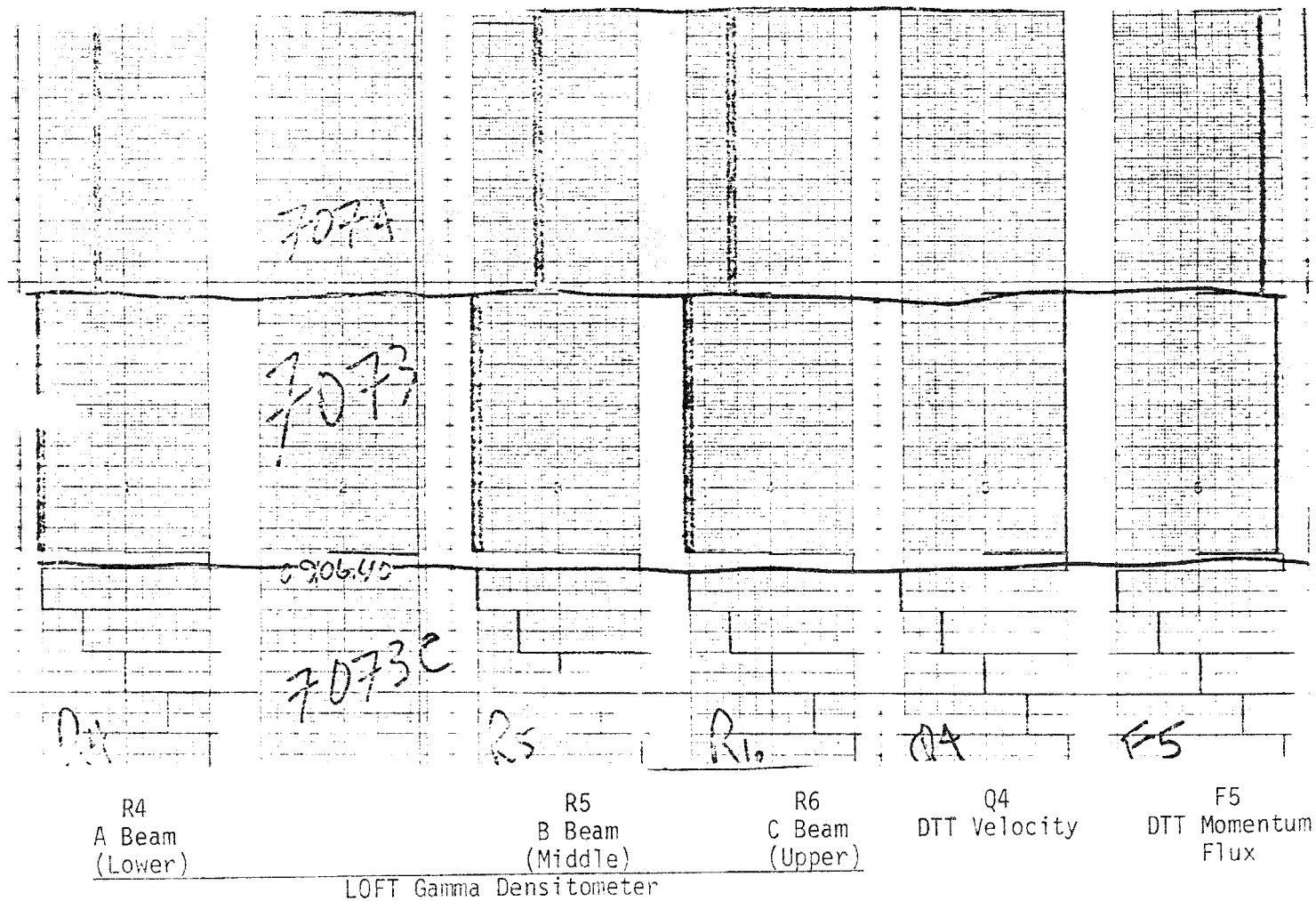
LTR 10-00-80-113

A4-34



LTR L0-00-80-113
KFK 2734

A4-35



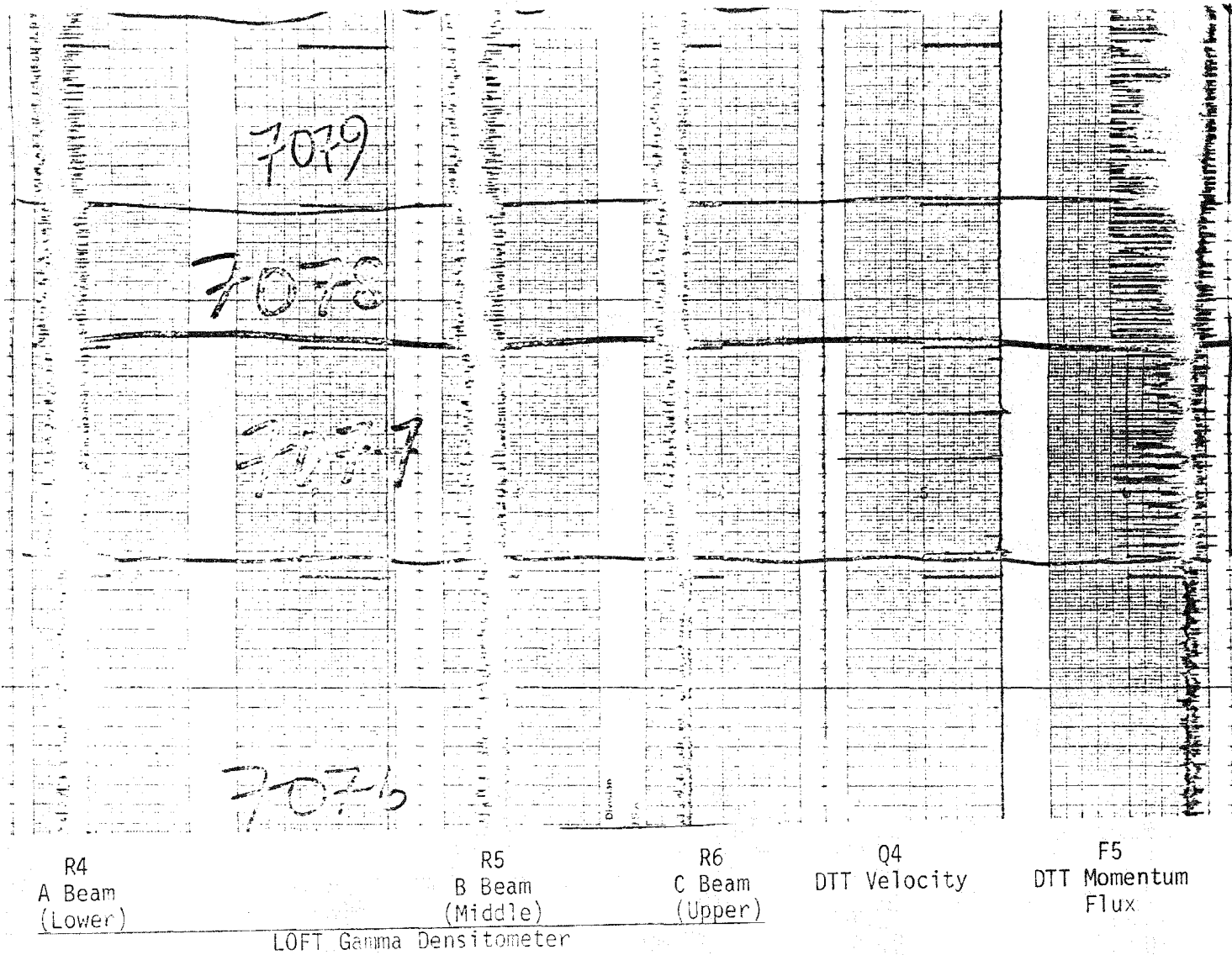
LTR LO-00-80.113

A4-36



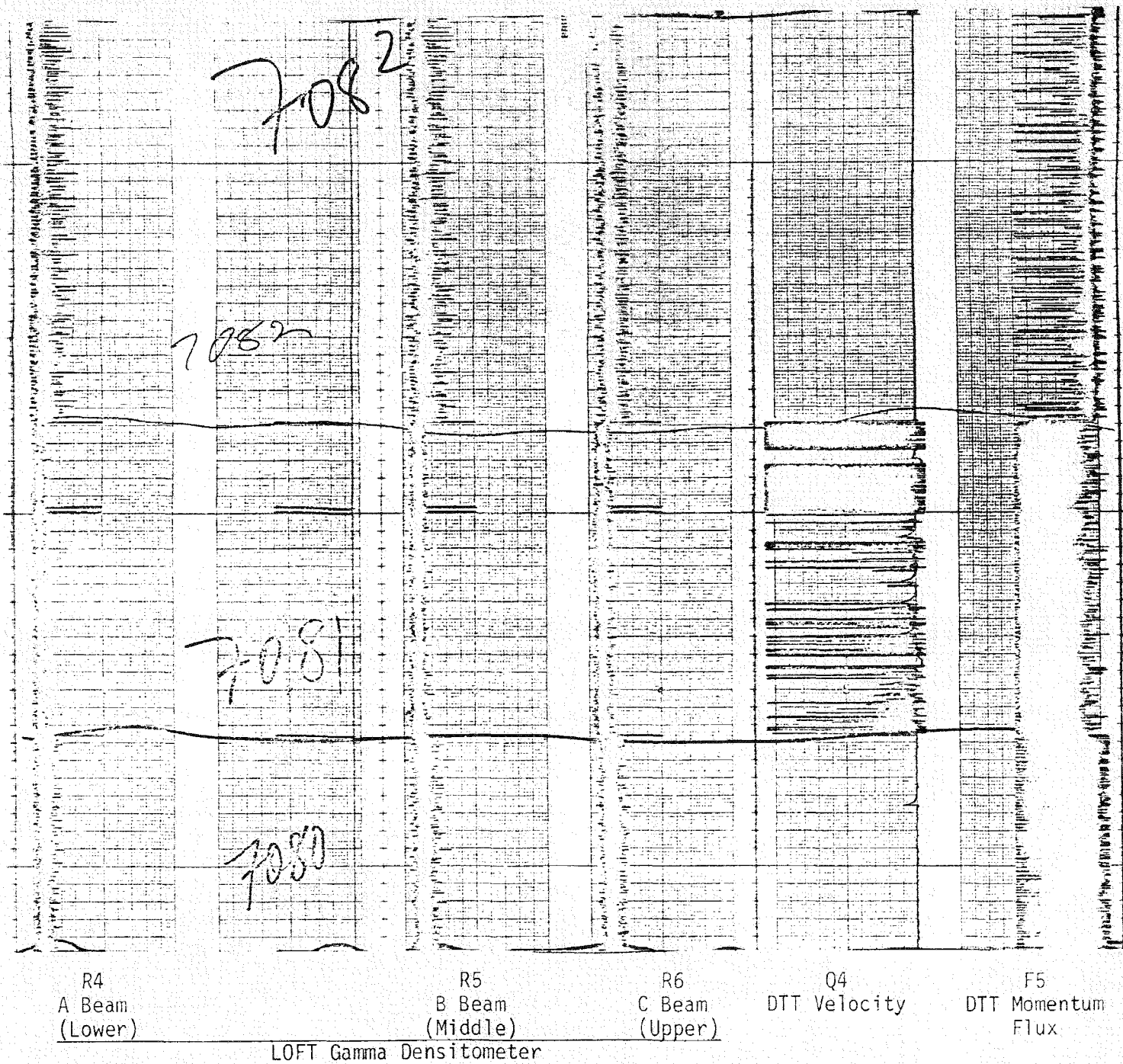
LTR LO-00-80-113
KFK 2784

A4-37

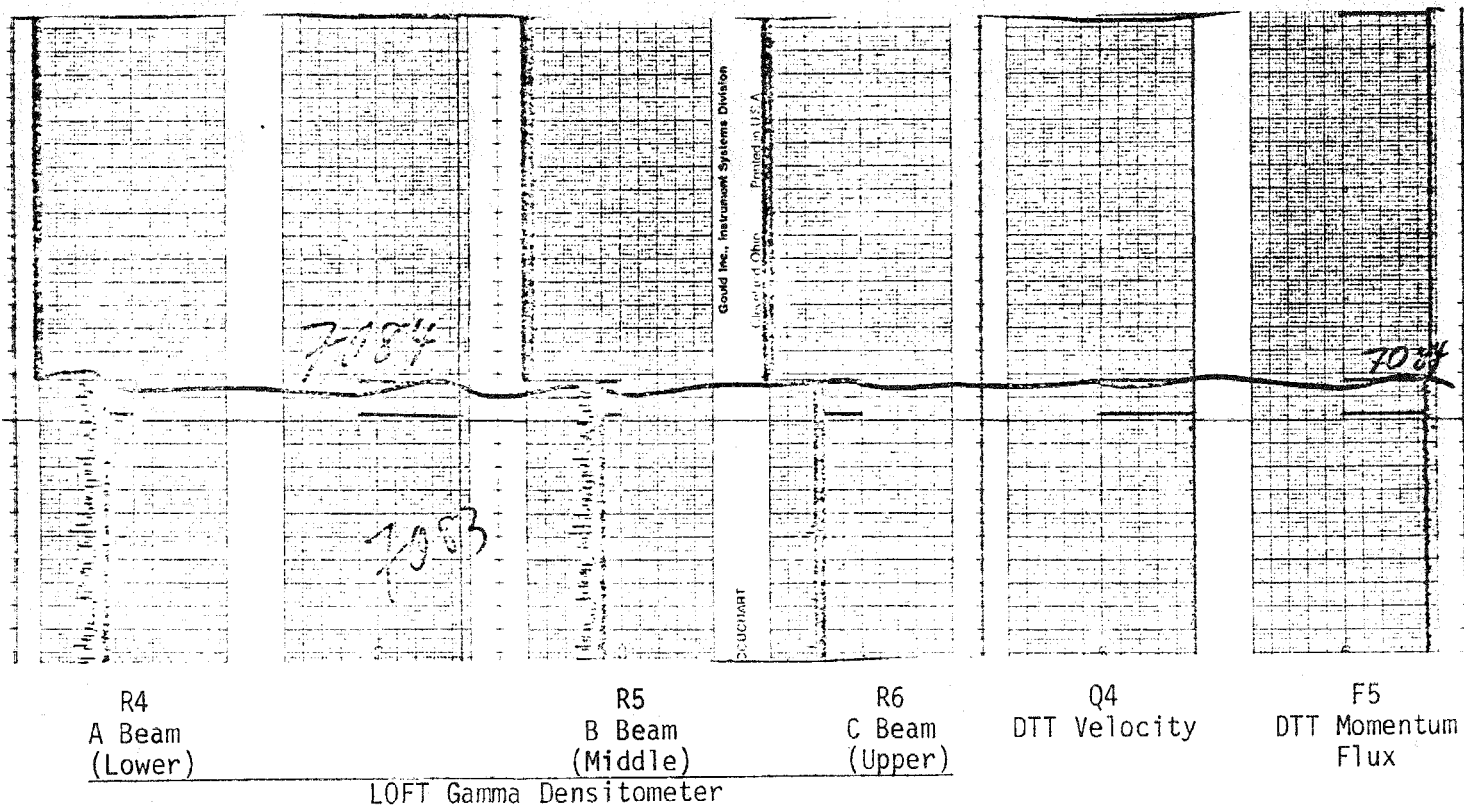


LTR LO-00-80-113
KFN 2784

LTR LO-00-80-113
KFK 2784



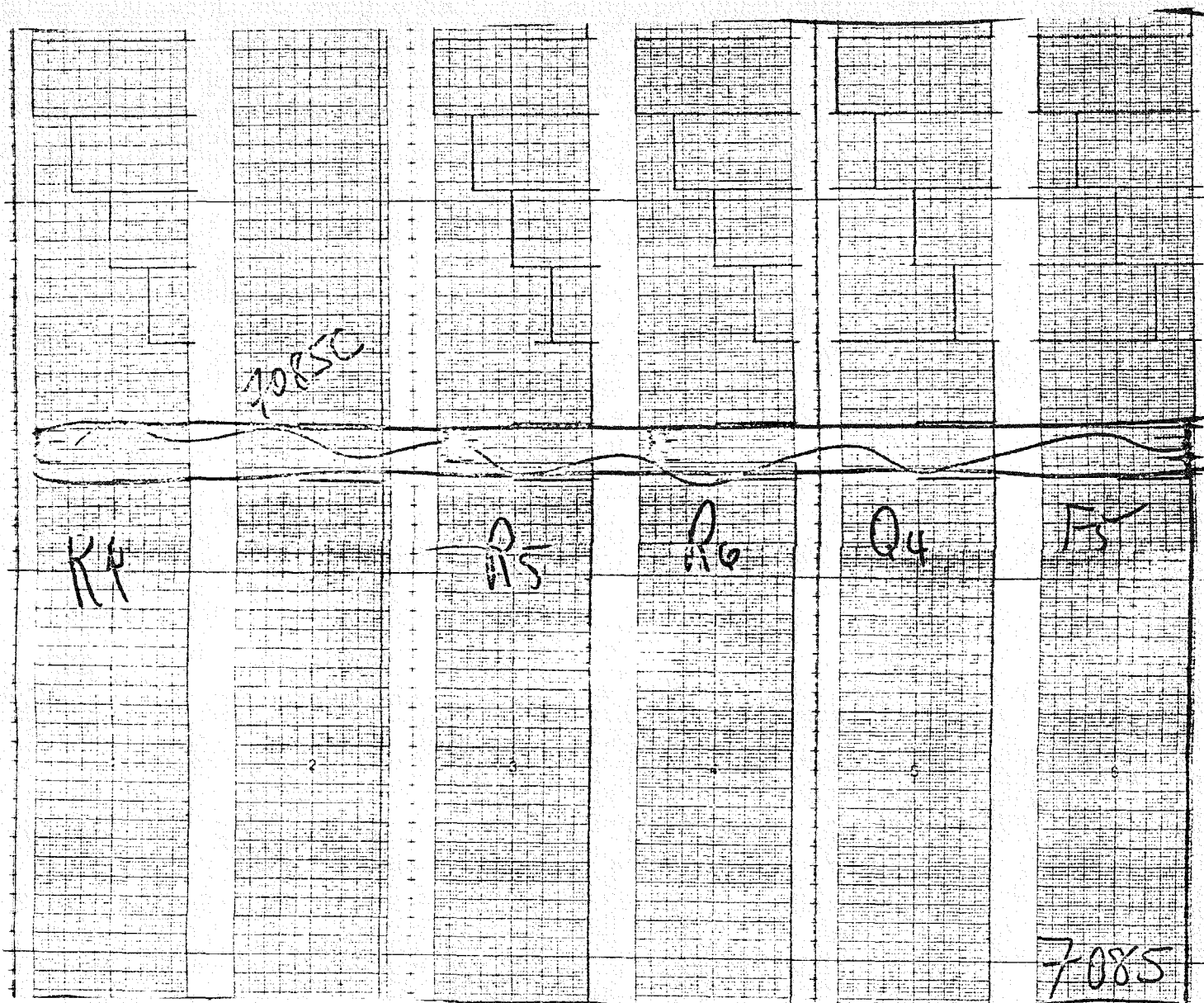
A4-39



KFK 2734

LTR LO-00-80-113

A4-40



R4
A Beam
(Lower)

R5
B Beam
(Middle)

LOFT Gamma Densitometer

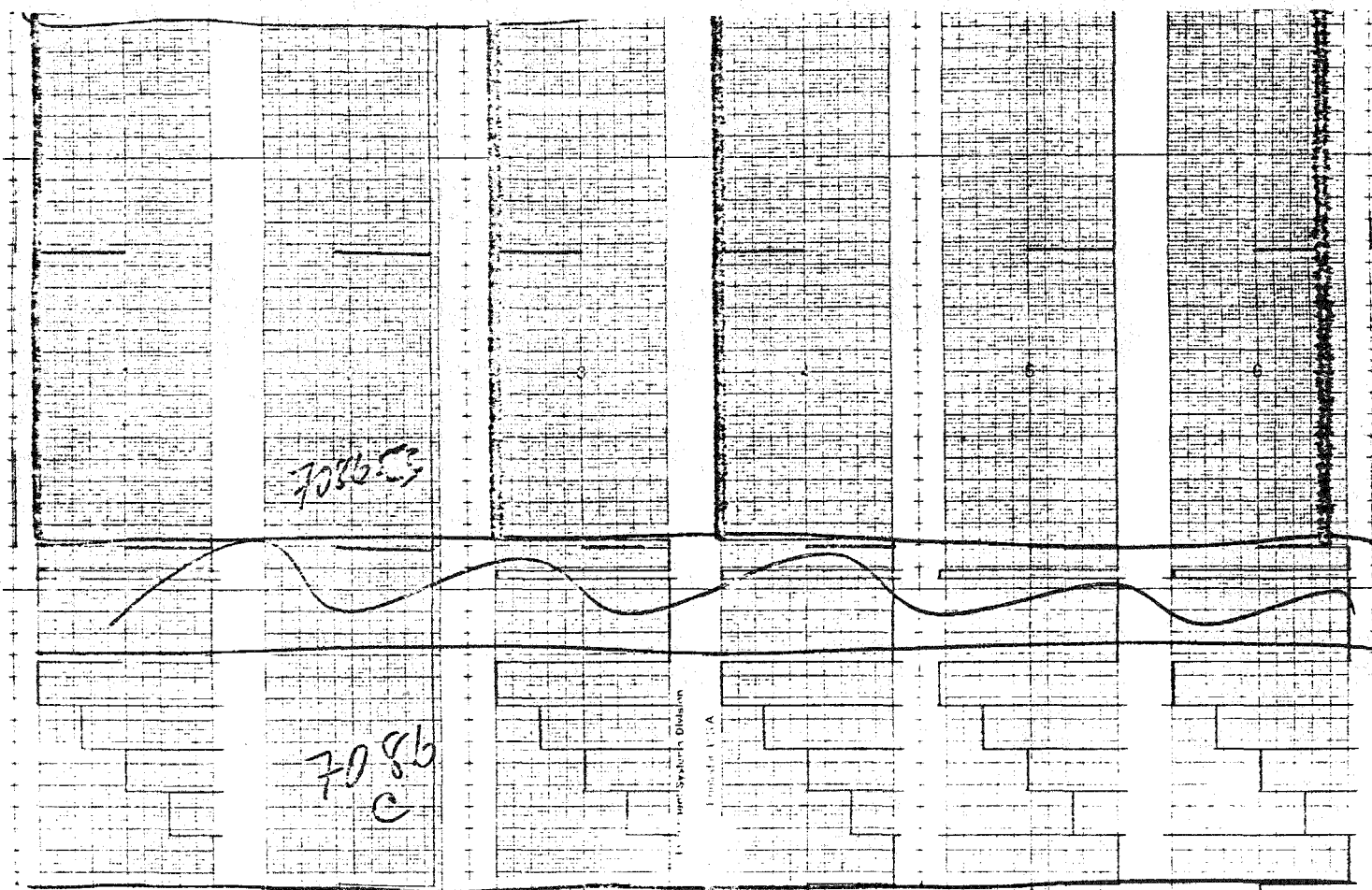
R6
C Beam
(Upper)

Q4
DTT Velocity

F5
DTT Momentum
Flux

LTR LO-00-80-113
KFK 2734

A4-41



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

Q4
DTT Velocity

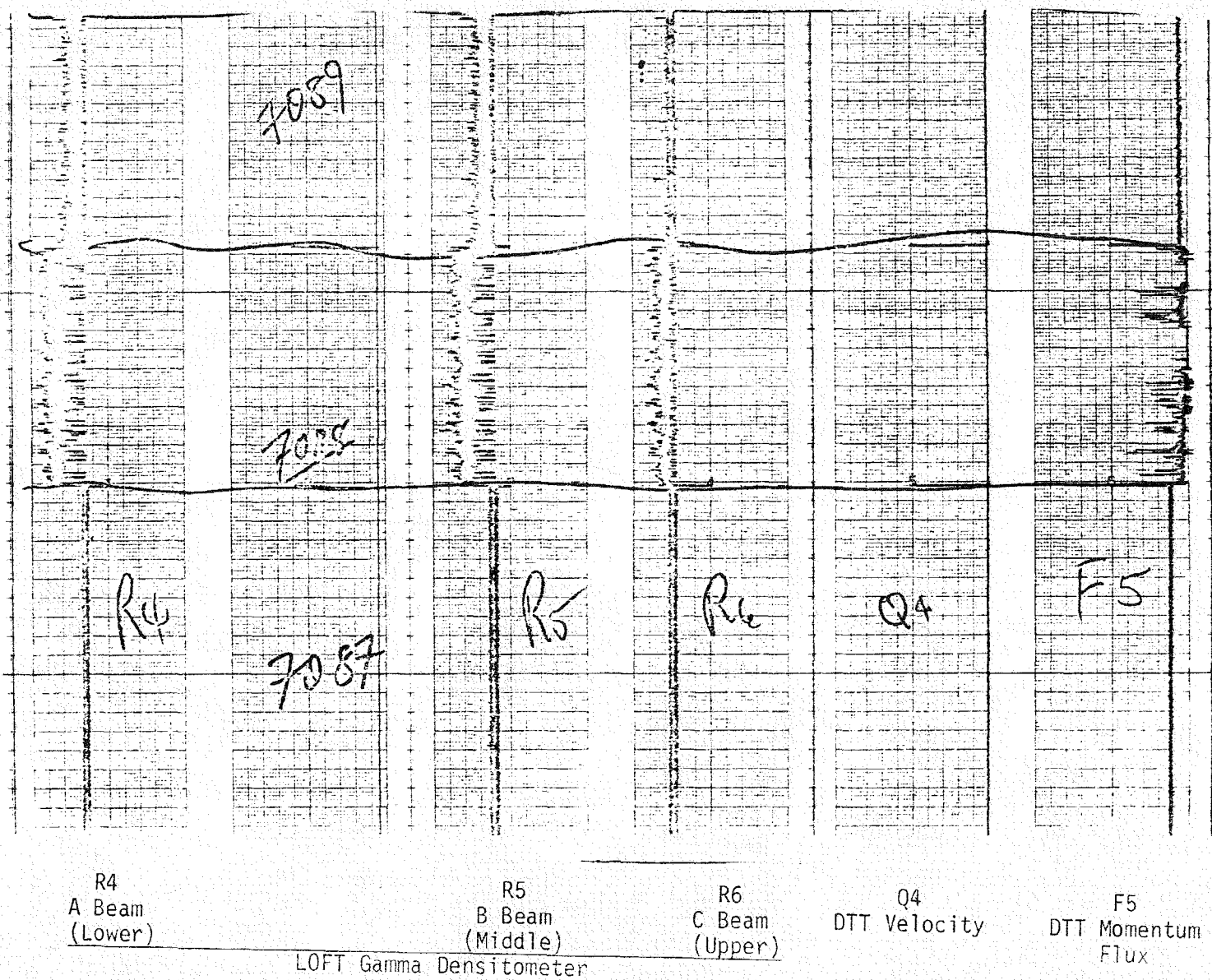
F5
DTT Momentum
Flux

LOFT Gamma Densitometer

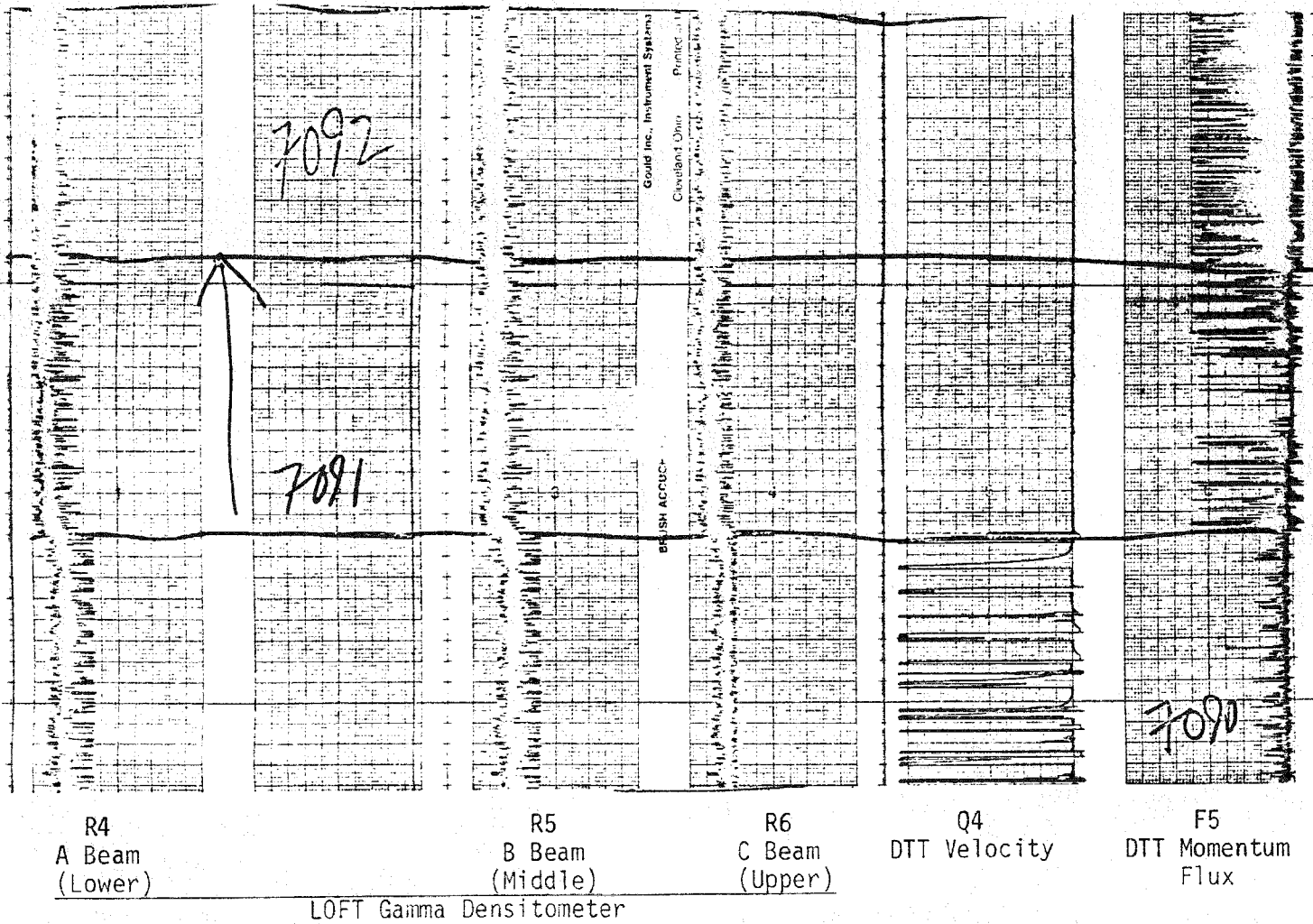
KFK 2734

LTR LO-00-80-113

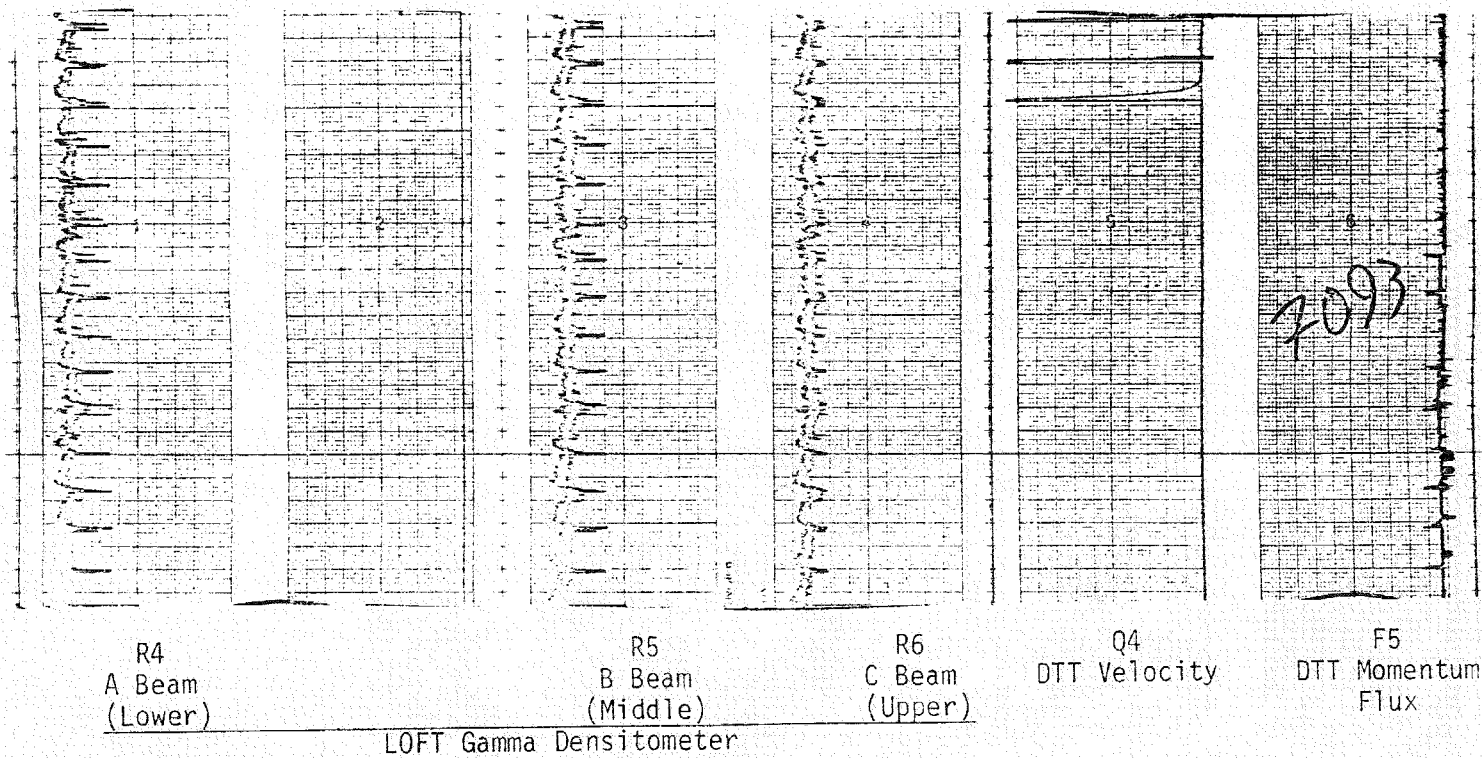
A4-42



LTR LO-00-80-113
KFK 2734



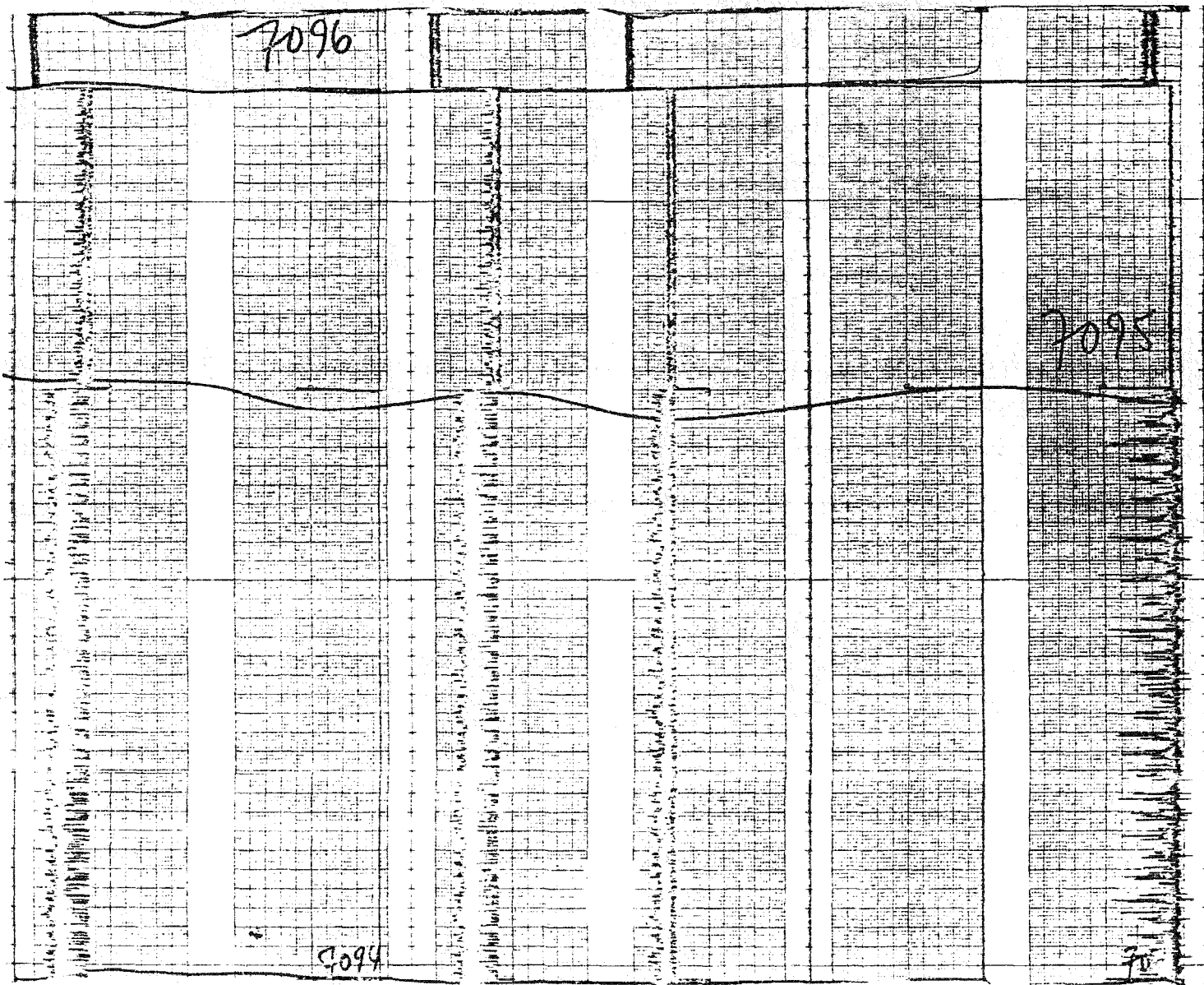
A4-44



LTR L0-00-80-113

LTR L0-00-80-113

KFK 2734



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

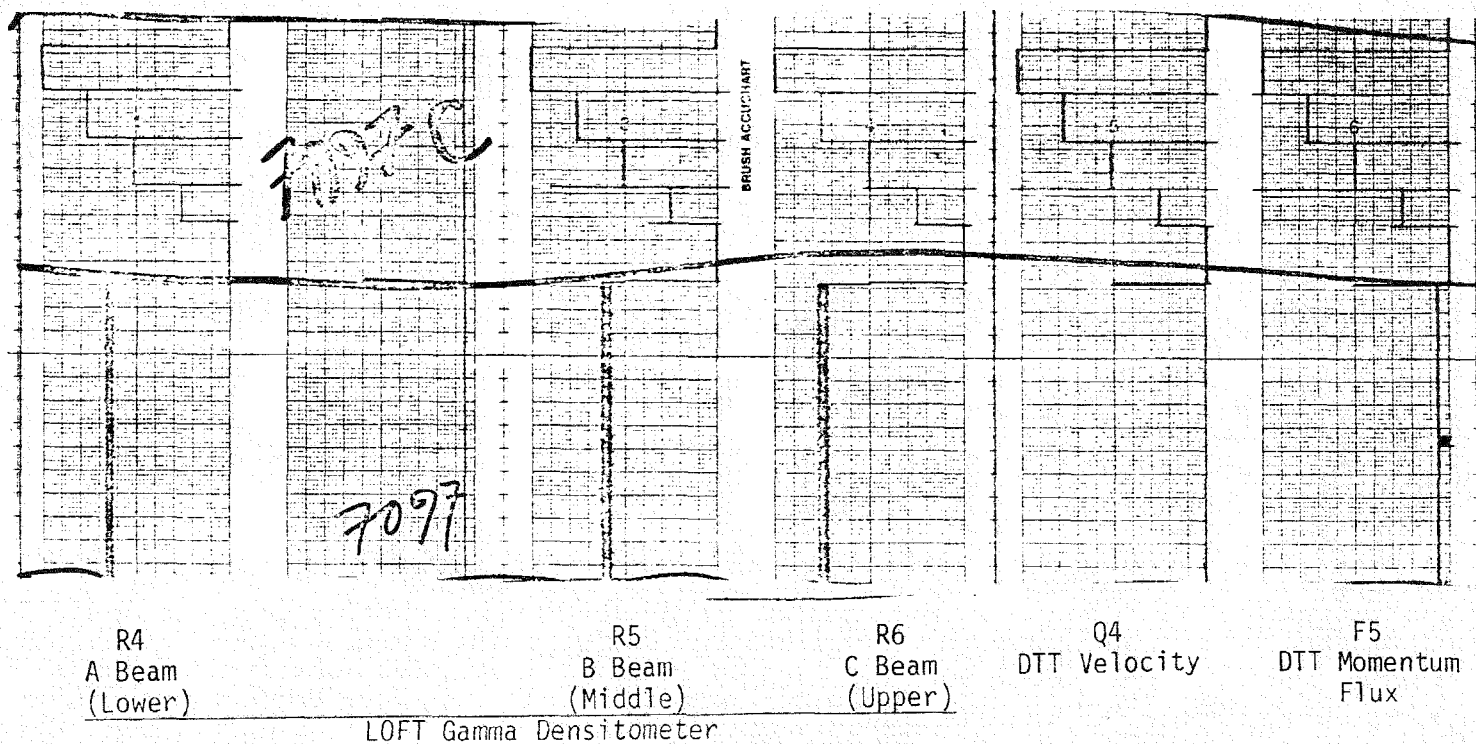
Q4
DTT Velocity

F5
DTT Momentum
Flux

LOFT Gamma Densitometer

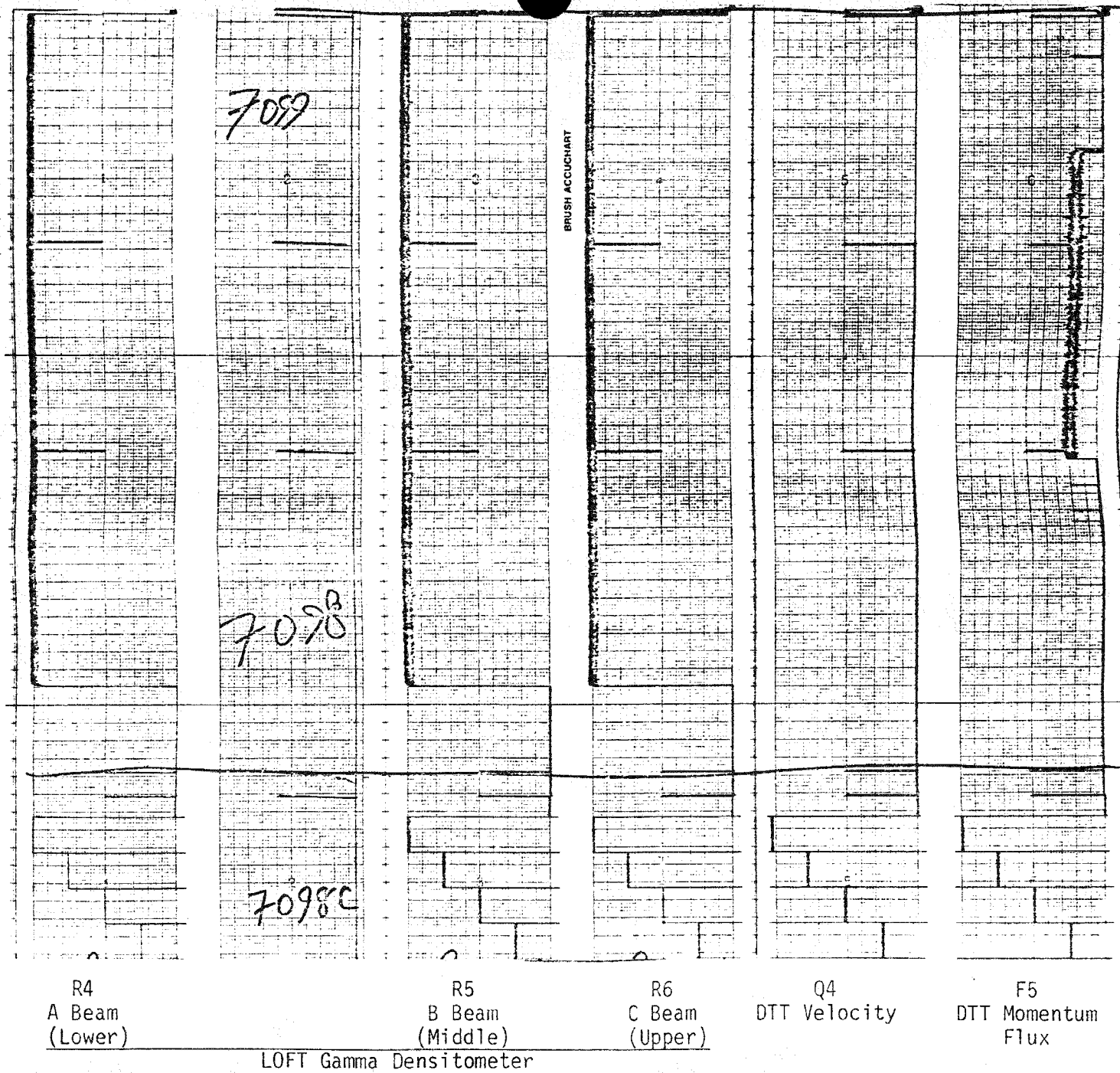
A4-45

A4-46



LTR L0-00-80-113

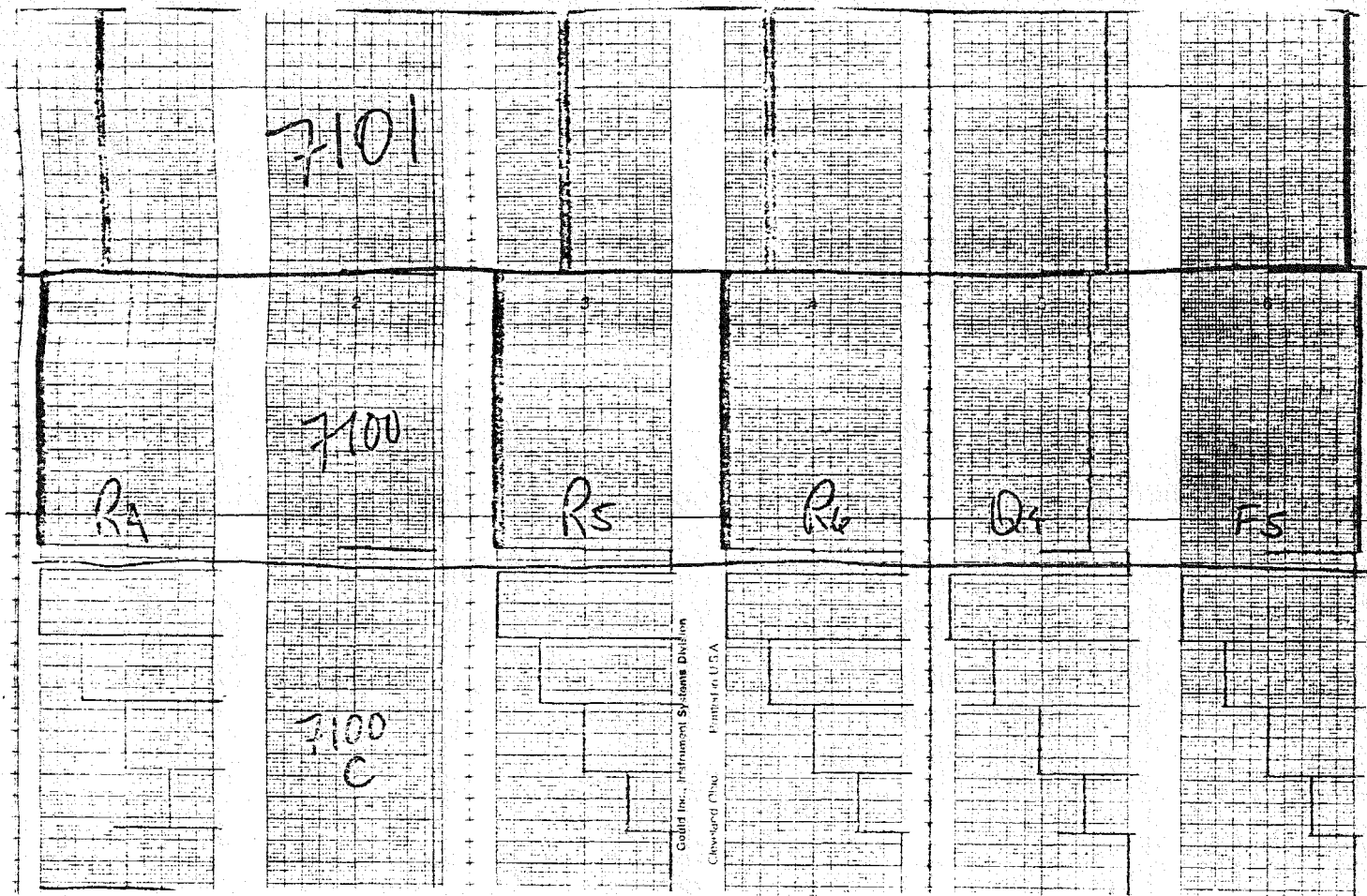
A4-47



KFK 2784

LTR L0-00-80-113

A4-48



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

Q4
DTT Velocity

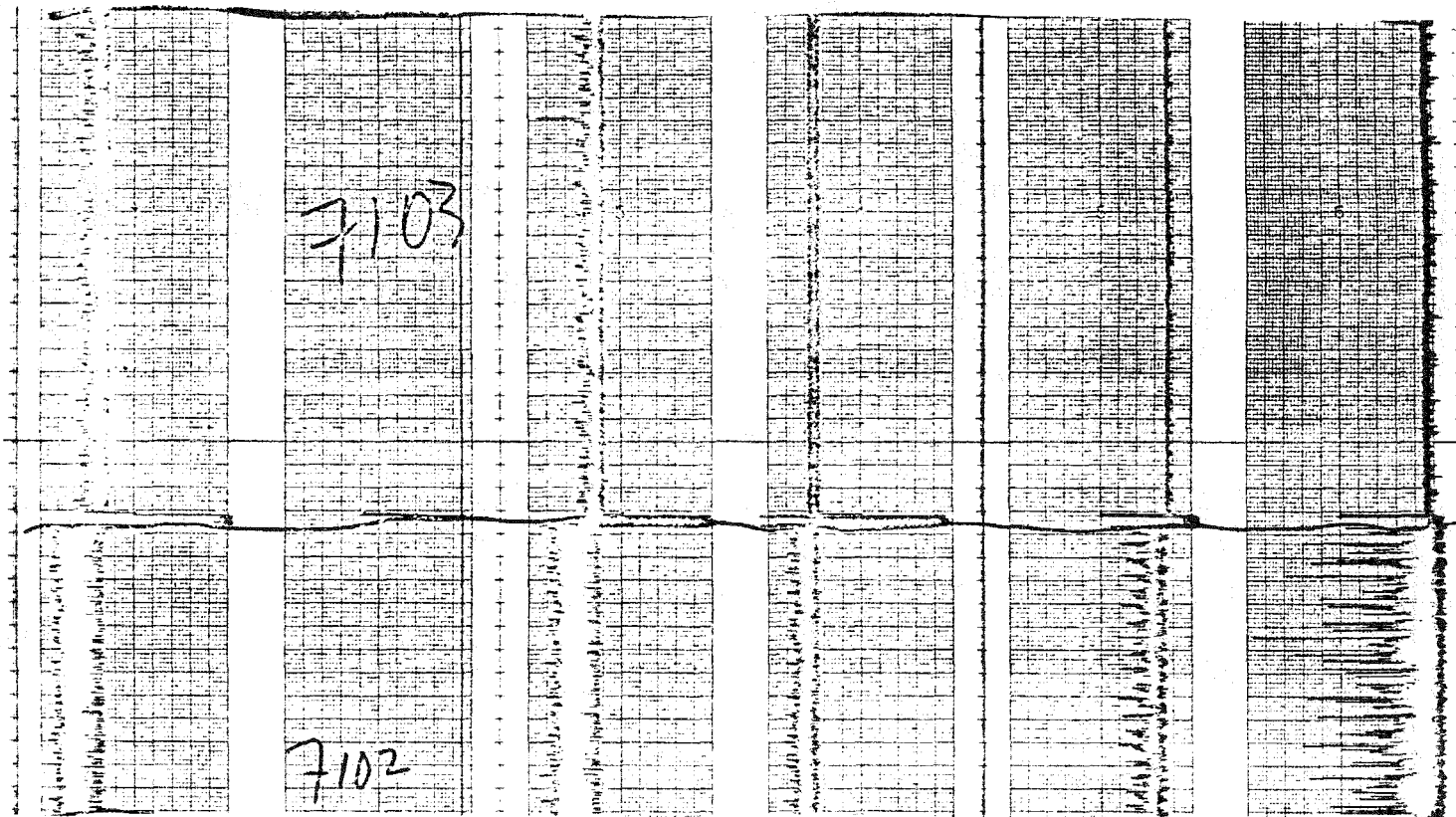
F5
DTT Momentum
Flux

LOFT Gamma Densitometer

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LTR 7700
LTR LO-00-80-113

A4-49



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

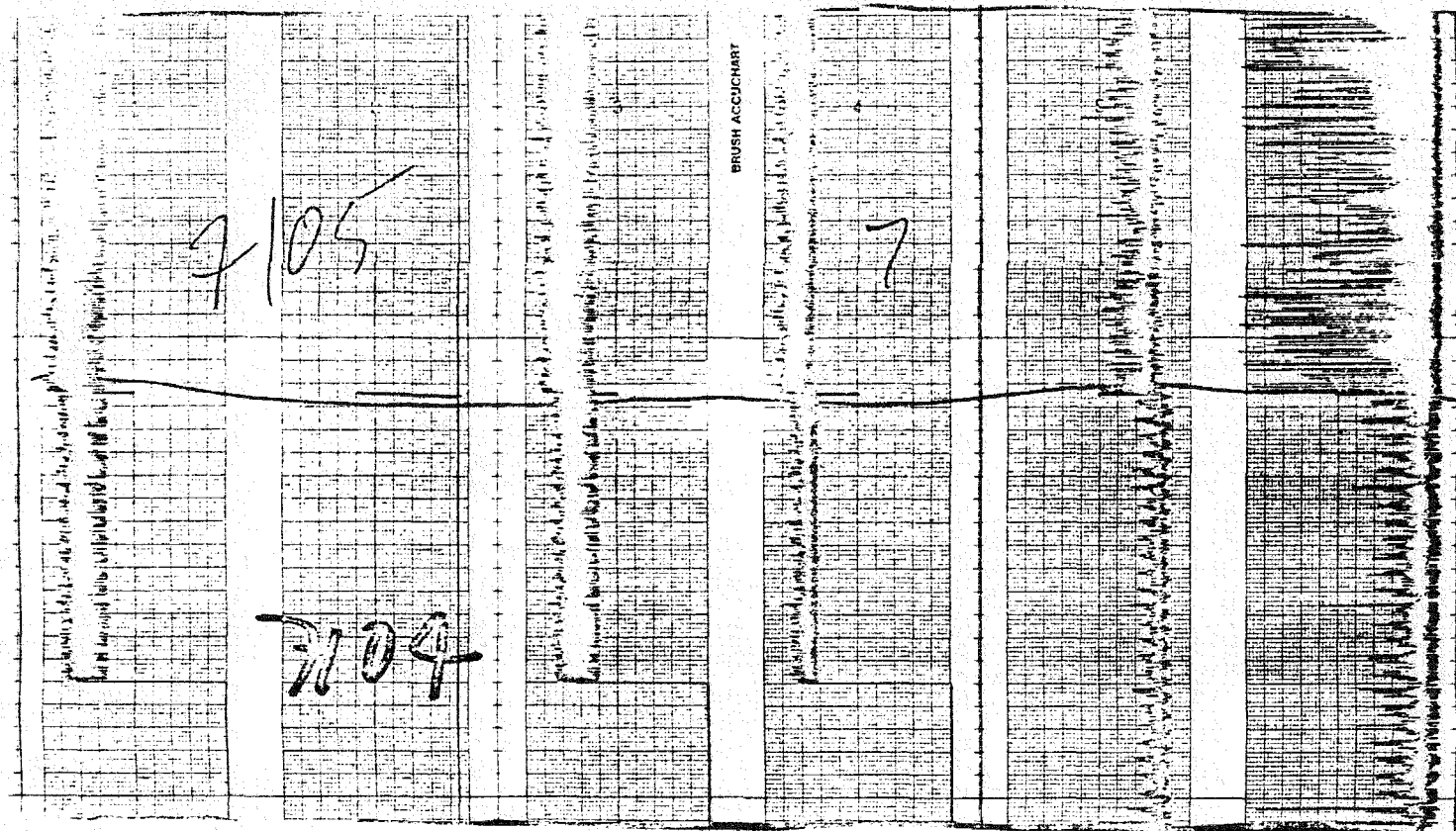
Q4
DTT Velocity

F5
DTT Momentum
Flux

LOFT Gamma Densitometer

LTR L0-00-80-113
KFK 2734

LTR L0-00-80-113



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

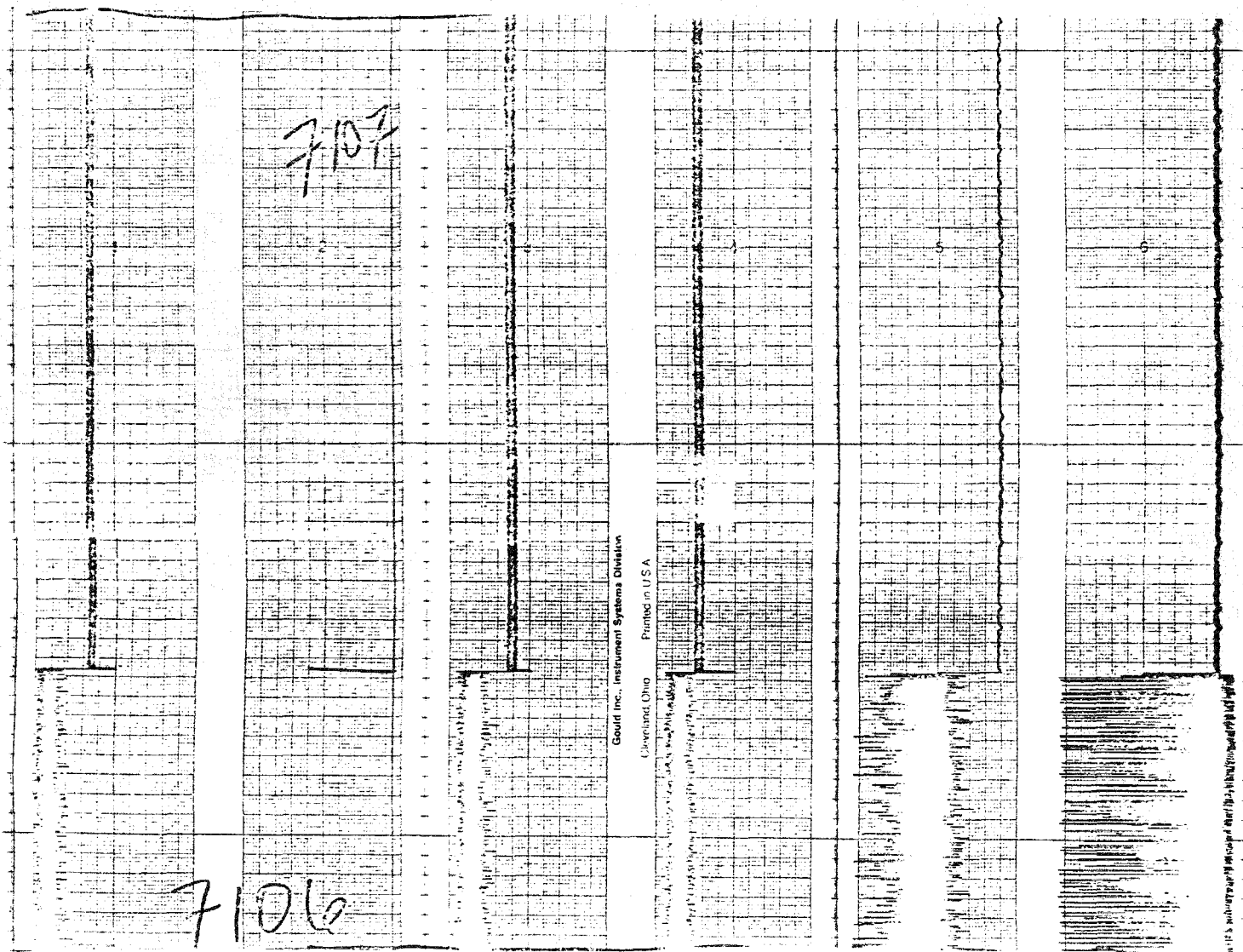
Q4
DTT Velocity

F5
DTT Momentum
Flux

LOFT Gamma Densitometer

A4-50

LTR LO-00-80-113
KFK 2784



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

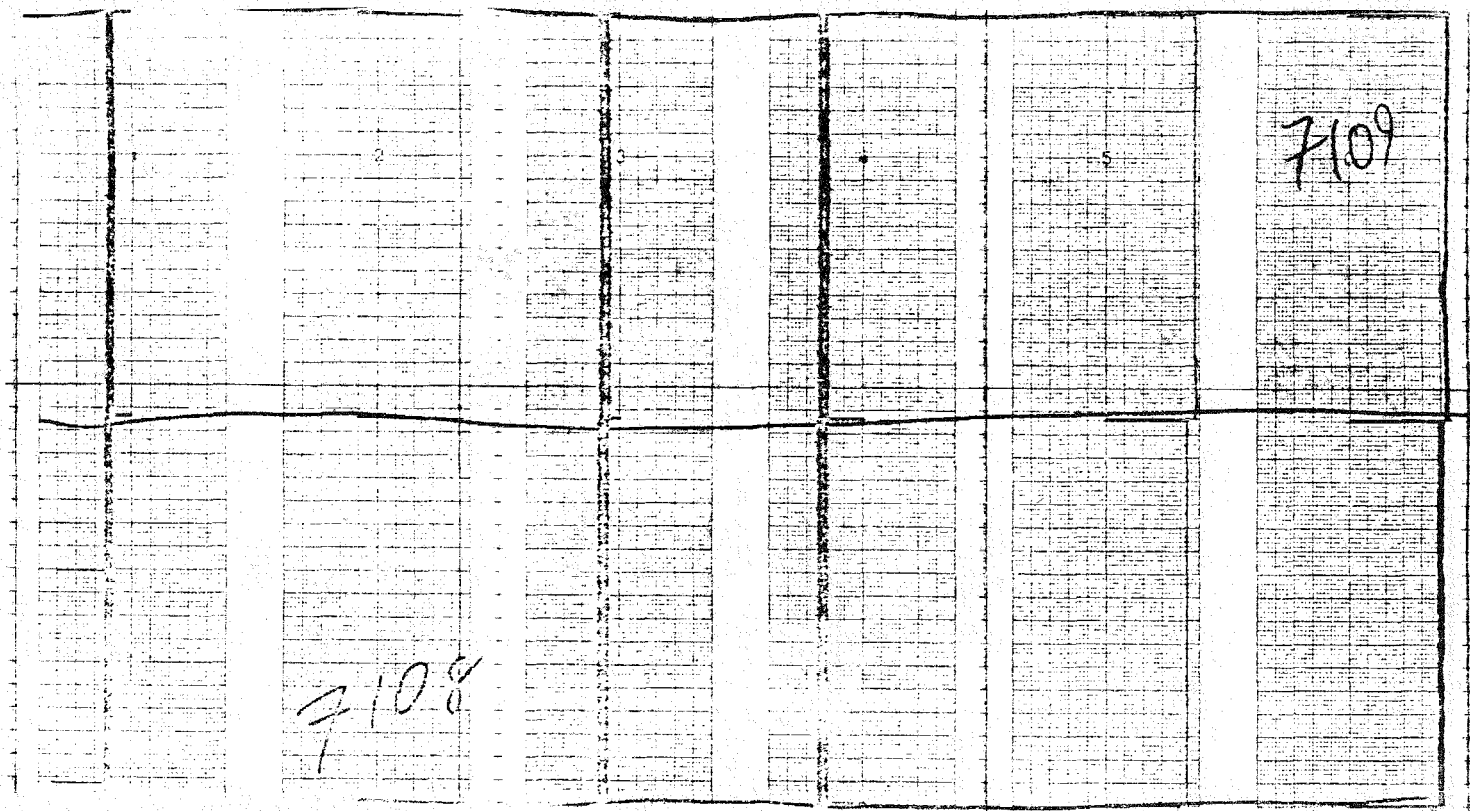
Q4
DTT Velocity

F5
DTT Momentum
Flux

LOFT Gamma Densitometer

A4-51

A4-52



R4
A Beam
(Lower)

R5
B Beam
(Middle)

R6
C Beam
(Upper)

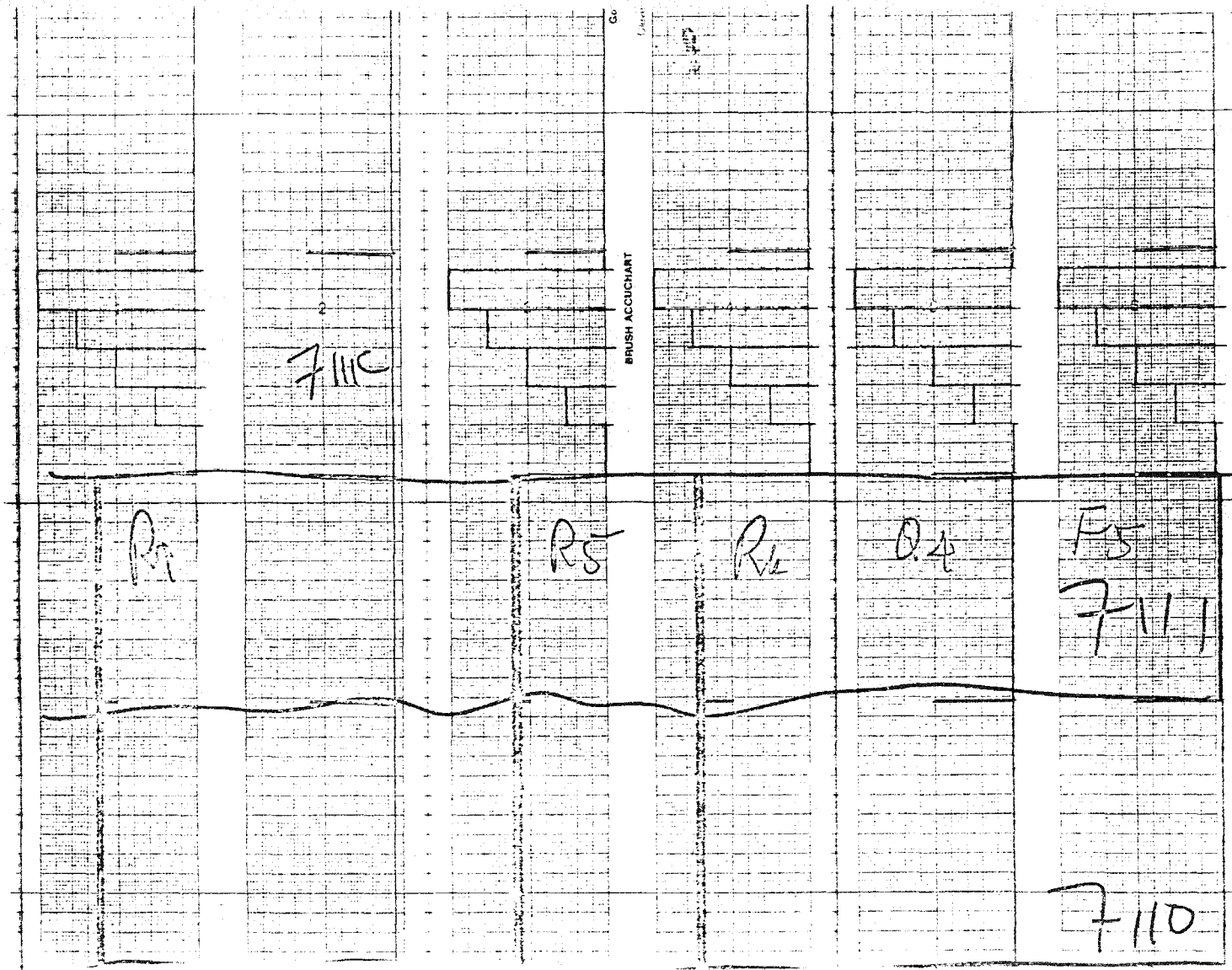
Q4
DTT Velocity

F5
DTT Momentum
Flux

LOFT Gamma Densitometer

LTR LO-00-80-113

A4-53



R4
A Beam
(Lower)

R5
B Beam
(Middle)
LOFT Gamma Densitometer

R6
C Beam
(Upper)

Q4
DTT Velocity

F5
DTT Momentum
Flux

LTP LO-00-80.113
KFK 2/84

APPENDIX 5

EG&G TIME AVERAGED DIGITIZED ANALOG DATA

(Voltages)

The following table lists the voltage outputs from the turbine, drag disk, and the 3 beams of the LOFT gamma densitometer. The voltages reported are on a range of 0 to 10 volts, as determined by calibrations.

Errors in some voltages reported here have been corrected in the data reported in the data chapters.

Input Voltages

	<u>Turbine</u>	<u>Drag Disk</u>	<u>A Beam</u>	<u>B Beam</u>	<u>C Beam</u>
7000	.0355	.2315	6.655	5.918	7.002
7001	.7255	.8162	6.018	5.534	6.968
7002	1.378	2.329	5.947	5.515	6.974
7003	1.879	4.199	5.901	5.516	6.975
7004	2.746	5.935	5.904	5.513	6.989
7005	3.469	5.948	5.898	5.512	6.989
7006	4.244	5.954	5.901	5.523	7.024
7007	4.941	5.959	5.909	5.527	7.035
7008	5.72	5.964	5.93	5.513	7.006
7009	5.814	5.969	5.916	5.53	7.031
7010	6.277	5.975	5.894	5.513	7.03
7011	5.662	5.976	5.91	5.523	7.045
7012	4.978	5.969	5.913	5.514	7.034
7013	4.558	5.972	5.926	5.511	7.03
7014	3.896	5.97	5.891	5.503	7.041
7015	3.191	5.971	5.895	5.499	7.032
7016	2.385	5.956	5.899	5.495	7.037
7017	1.732	3.387	5.95	5.506	7.053
7018	1.727	3.354	- .0324	.0558	- .0041
7019	1.122	1.488	5.931	5.493	7.059
7020	.1013	.288	6.514	5.806	7.117
7021	.1117	- .1741	6.574	- .0341	- .0628
7022	.0218	- .2337	6.587	6.13	7.417
7023	.0478	- .2481	6.486	6.055	7.351
7024	.0502	.0947	6.435	6.024	7.346
7025	.1297	.1732	6.536	6.126	7.424
7026	.1359	.209	6.538	6.112	7.413
7027	.2868	.3122	6.571	6.131	7.412
7028	.7456	.7939	6.579	6.142	7.423
7029	.4283	.4524	6.628	6.183	7.484
7030	.5686	.5921	6.591	6.149	7.44

Input Voltages

	<u>Turbine</u>	<u>Drag Disk</u>	<u>A Beam</u>	<u>B Beam</u>	<u>C Beam</u>
7031	.6607	.6995	6.561	6.142	7.443
7032	.8307	.926	6.604	6.155	7.437
7033	.454	.4952	6.624	6.163	7.444
7034	.2572	.3598	6.645	6.204	7.49
7035	1.873	1.401	8.662	7.955	8.179
7036	1.738	1.536	8.53	7.787	8.043
7037	1.353	1.406	8.091	7.384	7.756
7038	1.008	1.218	7.348	6.601	7.401
7039	1.633	1.401	8.504	7.66	8.124
7040	2.718	1.433	8.979	8.097	8.492
7041	.5263	.6133	7.047	6.268	7.696
7042	1.895	.4815	9.981	9.98	9.971
7043	.0547	1.105	6.691	6.328	7.368
7044	- .3516	.9037	6.704	6.328	7.351
7045	.0765	.7847	6.656	6.325	7.386
7046	.0819	.5591	6.533	6.261	7.421
7047	.0871	.467	6.593	6.275	7.376
7048	.0909	.4135	6.614	6.281	7.332
7049	.0961	.3499	6.512	6.216	7.359
7050	.0998	.4396	6.584	6.26	7.381
7051	.1057	.55	6.548	6.257	7.417
7052	.1069	.6977	6.612	6.27	7.357
7053	.1079	.9417	6.612	6.294	7.395
7054	.1141	1.051	6.626	6.294	7.398
7055	.1171	.3601	8.983	8.411	8.379
7056	.9839	.1981	1.315	1.329	1.255
7057	8.144	.7671	10.	10.05	9.95
7058	.9707	1.42	6.397	6.082	7.411
7059	1.121	1.586	7.088	6.584	7.479

Input Voltages

	<u>Turbine</u>	<u>Drag Disk</u>	<u>A Beam</u>	<u>B Beam</u>	<u>C Beam</u>
7060	1.522	2.006	8.005	7.389	7.781
7061	1.111	1.593	7.279	6.617	7.589
7062	2.318	1.837	8.772	8.081	8.38
7063	1.889	1.894	8.552	7.855	8.244
7064	5.409	1.941	-	8.701	8.856
7065	.9977	1.135	8.147	7.379	7.852
7066	.7398	.9498	6.835	6.219	7.568
7067	1.097	1.189	8.198	7.425	7.9
7068	1.702	1.224	8.977	8.17	8.375
7069	5.536	1.387	9.69	8.852	9.02
7070	.1187	.5012	10.38	9.804	10.08
7071	.1163	.8763	6.671	6.178	7.546
7073	.0539	.397	9.987	10.	10.02
7074	.0607	1.265	6.474	6.106	7.279
7075	.0719	1.428	8.187	7.66	7.879
7076	.0799	1.143	7.082	6.551	7.353
7077	.2068	1.375	7.864	7.337	7.661
7078	.0921	1.371	8.341	7.825	8.043
7079	.0885	1.413	8.886	8.335	8.391
7080	.0927	2.102	9.228	8.702	8.634
7081	1.206	3.704	9.433	8.981	9.154
7082	.1076	.694	9.19	8.53	8.486
7083	.1065	.532	6.816	6.24	7.313
7084	.1103	.2516	10.	9.944	10.09
7085	.1133	.2385	-.0054	-.0061	.015
7086	.0165	1.374	9.94	9.932	9.958
7087	.0315	1.236	6.462	6.117	7.402
7088	.0780	.5577	8.223	7.708	7.889
7089	.0364	.5361	7.066	6.543	7.434

KFR 2704Input Voltages

	<u>Turbine</u>	<u>Drag Disk</u>	<u>A Beam</u>	<u>B Beam</u>	<u>C Beam</u>
7090	3.846	.6411	8.015	7.508	7.779
7091	.109	.7664	8.985	8.514	8.591
7092	.1082	1.271	9.348	8.868	8.898
7093	.1167	.363	8.677	8.162	8.339
7094	.1182	.8229	8.096	7.585	7.917
7095	.1234	.6706	6.61	6.124	7.512
7096	.1265	2.218	9.898	9.898	10.25
7097	.1197	.6625	6.384	5.996	7.493
7098	.0738	1.972	10.	10.	10.85
7099	.0784	1.967	10.	10.	10.83
7100	2.186	- .417	9.945	9.951	9.989
7101	1.247	.3779	6.424	6.092	7.418
7102	2.011	.5312	8.241	7.739	7.946
7103	1.233	.3063	6.786	6.314	7.493
7104	1.788	.4687	7.895	7.344	7.68
7105	2.566	.7678	8.535	8.056	8.258
7106	6.026	1.16	9.216	8.713	8.676
7107	1.278	.3887	6.484	6.096	7.368
7108	.8417	- .1082	6.274	5.898	7.213
7109	.4088	- .3924	6.189	5.816	7.184
7110	.1221	- .5027	6.199	5.828	7.188
7111	.1226	- .4322	6.203	5.842	7.203
7112	6.155	- .1081	9.947	9.938	10.01
7113	1.853	- .4892	9.951	9.876	9.982
7114	1.203	.2715	6.562	6.175	7.375
7115	1.033	.1189	6.685	6.178	7.369
7116	.8565	- .0466	6.627	6.191	7.367
7117	.6718	- .1973	6.643	12.57	12.96
7118	.4098	- .3592	6.648	6.261	7.45
7119	1.613	.3406	7.832	7.249	7.635

Input Voltages

	<u>Turbine</u>	<u>Drag Disk</u>	<u>A Beam</u>	<u>B Beam</u>	<u>C Beam</u>
7120	1.497	.3598	7.597	6.968	7.652
7121	2.259	.5253	8.475	7.822	8.056
7122	2.558	.5563	8.631	8.005	8.151
7123	3.924	.6826	9.05	8.397	8.319
7124	1.261	-.4732	10.09	9.734	9.814
7125	.8512	-.0821	6.673	6.208	7.527
7126	1.962	-.4716	9.91	9.927	10.16
7127	1.121	.1944	6.35	6.091	7.547
7128	3.824	-.0491	8.609	8.134	8.387
7129	3.594	.1389	8.881	8.46	8.901
7130	4.289	.2338	9.038	8.594	9.012
7131	1.672	-.0510	8.348	7.797	8.267
7132	1.137	-.1254	7.849	7.231	7.947
7133	1.023	-.0946	7.567	6.927	7.858
7134	.9952	-.1074	7.412	6.761	7.821
7135	.687	-.342	7.338	6.665	7.763
7136	.7035	-.3315	7.475	6.832	7.804
7137	.7324	-.3112	7.718	7.053	7.83
7138	1.08	-.0751	8.287	7.547	8.14