ornl

OAK RIDGE NATIONAL LABORATORY

UNION CARBIDE

MASTER

NUREG/CR-1011
ORNL/NUREG/TM-350

# Steady-State Axial Pressure Losses Along the Exterior of Deformed Fuel Cladding: Multirod Burst Test (MRBT) Bundles B-1 and B-2

J. F. Mincey



Prepared for the U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Under Interagency Agreements DOE 40-551-75 and 40-552-75

OPERATED BY
UNION CARBIDE CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161

NUREG/CR-1011
ORNL/NUREG/TM-350
Dist. Category R3

Contract No. W-7405-eng-26

Engineering Technology Division

# STEADY-STATE AXIAL PRESSURE LOSSES ALONG THE EXTERIOR OF DEFORMED FUEL CLADDING: MULTIROD BURST TEST (MRBT) BUNDLES B-1 AND B-2

J. F. Mincey

Manuscript Completed — December 20, 1979
Date Published — January 1980

NOTICE: This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

Prepared for the
U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Under Interagency Agreements DOE 40-551-75 and 40-552-75

NRC FIN No. B0120

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
DEPARTMENT OF ENERGY

CONTENTS

Page

# FOREWORD

This report summarizes results and analyses of flow characterization tests conducted with Multirod Burst Test Program (MRBT) bundles B-1 and B-2. Summary results of these tests have been reported routinely in the MRBT progress reports. While this procedure disseminates the information as it is developed, there are drawbacks in that the results and any revisions made after further analysis are scattered among several reports. In order to alleviate these shortcomings and because these results are believed to be of sufficient importance to warrant it, they are being published in a single document.

The MRBT Program at Oak Ridge National Laboratory is sponsored by the Division of Reactor Safety Research of the Nuclear Regulatory Commission. Progress reports issued by this program are listed below:

| NUREG Report No. | ORNL Report No. | Period Covered |
|---|---|---|
| | ORNL/TM-4729 | July—September 1974 |
| | ORNL/TM-4805 | October—December 1974 |
| | ORNL/TM-4914 | January—March 1975 |
| | ORNL/TM-5021 | April—June 1975 |
| | ORNL/TM-5514 | July—September 1975 |
| | ORNL/NUREG/TM-10 | October—December 1975 |
| | ORNL/NUREG/TM-36 | January—March 1976 |
| | ORNL/NUREG/TM-74 | April—June 1976 |
| | ORNL/NUREG/TM-77 | July—September 1976 |
| | ORNL/NUREG/TM-95 | October—December 1976 |
| | ORNL/NUREG/TM-108 | January—March 1977 |
| | ORNL/NUREG/TM-135 | April—June 1977 |
| NUREG/CR-0103 | ORNL/NUREG/TM-200 | July—December 1977 |
| NUREG/CR-0225 | ORNL/NUREG/TM-217 | January—March 1978 |
| NUREG/CR-0398 | ORNL/NUREG/TM-243 | April—June 1978 |
| NUREG/CR-0655 | ORNL/NUREG/TM-297 | July—December 1978 |
| NUREG/CR-0817 | ORNL/NUREG/TM-323 | January—March 1979 |
| NUREG/CR-1023 | ORNL/NUREG/TM-351 | April—June 1979 |

Topical reports pertaining to research and development carried out as a part of this program are:

1. R. H. Chapman (Comp.), *Characterization of Zircaloy-4 Tubing Procured for Fuel Cladding Research Programs*, ORNL/NUREG/TM-29 (July 1976).

2. W. E. Baucum and R. E. Dial, *An Apparatus for Spot Welding Sheathed Thermocouples to the Inside of Small-Diameter Tubes at Precise Locations*, ORNL/NUREG/TM-33 (August 1976).

3. W. A. Simpson, Jr., et al., *Infrared Inspection and Characterization of Fuel Pin Simulators*, ORNL/NUREG/TM-55 (November 1976).

4. R. H. Chapman et al., *Effect of Creep Time and Heating Rate on Deformation of Zircaloy-4 Tubes Tested in Steam with Internal Heaters*, NUREG/CR-0343 (ORNL/NUREG/TM-245) (October 1978).


The following limited-distribution quick-look and data reports have been issued by this program:


1. R. H. Chapman, (Comp.), *Quick-look Report on MRBT No. 1 4 × 4 Bundle Burst Test*, Internal Report ORNL/MRBT-2 (September 1977).

2. R. H. Chapman, (Comp.), *Quick-look Report on MRBT No. 2 4 × 4 Bundle Burst Test*, Internal Report ORNL/MRBT-3 (November 1977).

3. R. H. Chapman, *Quick-look Report on MRBT No. 3 4 × 4 Bundle Burst Test*, Internal Report ORNL/MRBT-4 (August 1978).

4. R. H. Chapman et al., *Bundle B-1 Test Data,* ORNL/NUREG/TM-322 (June 1979).

5. R. H. Chapman et al., *Bundle B-2 Test Data*, ORNL/NUREG/TM-337 (August 1979).

# STEADY-STATE AXIAL PRESSURE LOSSES ALONG THE EXTERIOR OF DEFORMED FUEL CLADDING: MULTIROD BURST TEST (MRBT) BUNDLES B-1 AND B-2

J. F. Mincey

## ABSTRACT

The experimental and COBRA-IV computational data presented in this report confirm that increased pressure losses, induced by the steady-state axial flow of water exterior to deformed Multirod Burst Test (MRBT) bundles B-1 and B-2, may be closely predicted using a bundle-averaged approach for describing flow channel restrictions. One anomaly that was encountered using this technique occurred while modeling the B-2 flow test data near a severe channel restriction: the COBRA-IV results tended to underestimate experimental pressure losses.

Keywords: Hydraulics, pressure losses, reactor fuel, cladding, experimental data, computer modeling.

---

## 1. INTRODUCTION

The general guidelines[1] for the Multirod Burst Test (MRBT) Program allude to a series of flow tests to experimentally determine pressure losses induced by post-burst-test cladding deformation. Accordingly, the following objectives were established for the MRBT flow test effort:

- Provide an experimental data base in which the pressure losses of a burst bundle are compared with those of an undeformed bundle under similar hydraulic conditions.
- Determine the geometrical details necessary for modeling these experimental data with COBRA-IV (ref. 2).

Inasmuch as additional MRBT bundle tests are in progress at this writing, this report will concentrate on B-1 and B-2 bundle data in meeting these objectives.

Since the MRBT Program is primarily concerned with the cladding deformation associated with a loss-of-coolant accident (LOCA) and not with a detailed investigation of the effect of such deformation on the actual thermal-hydraulic performance of the bundles, it was considered outside the scope of the program to construct a flow facility designed to produce thermal-hydraulic conditions typical of a LOCA. Instead, it was judged sufficient to characterize the flow behavior of both deformed and undeformed bundles in a flow facility used for another research program. Hence, the single-phase, steady-state water flow conditions were dictated in part by the available equipment rather than by technical considerations. These restraints had two detrimental effects on the data to be presented in this report. First, the quality and calibration of the available equipment were limited because the equipment was not available to the MRBT Program continuously. Second, the flow test data are limited in range and are directly applicable to only a very small class of postulated LOCA conditions.

However, with the demonstration of COBRA-IV's ability to predict measured pressure losses to within experimental uncertainty, a computational technique has been identified which may be validated against more applicable, non-MRBT experimental data in analyzing other categories of hydraulic systems. The intent of this report, then, is to document the uncertainties in the experimental data with which COBRA-IV results are compared, to describe how the MRBT COBRA-IV models were developed, and to compare COBRA-IV predictions with measured pressure losses.

# 2. EXPERIMENTAL FLOW FACILITY

The experimental flow facility is a closed flow loop circulating room-temperature (20 to 35°C) water at pressures less than 300 kPa above atmospheric. Water flow along the bundle axes is directed vertically upwards toward the flanged end of the burst bundles (i.e., opposite the direction of steam flow during the burst tests). The flow test facility, which is entirely independent of the burst test facilities, is shown in Fig. 2.1, with a view of the MRBT test stand in the foreground; the flow loop piping is in the background.

The test stand was designed in such a way that it could be quickly disconnected from the main flow loop piping. In fact, the main obstacle encountered in converting the loop back to its non-MRBT functions was associated with instrumentation modifications. The instrumentation used for these tests consisted of three pressure transducers and associated electronics, a turbine meter (with its electronics) downstream from the test stand, and a magnetic flow meter upstream of the test stand. The test stand and instrumentation of the test facility are examined in detail in the remaining sections of this chapter.

## 2.1 MRBT Flow Test Stand

For discussional purposes, the test stand will be broken down into eight types of components, seven of which are shown in Fig. 2.1: the lower transition section (A), the lower flow shroud (B), the bundle extension (C), the manifolds and connecting tubing (D), the upper flow shroud (E), the upper transition section (F), and the jackscrew retaining mechanism (G). These seven items are also illustrated in Figs. 2.2 to 2.10. The eighth item, the reference bundle, is shown in Fig. 2.11. These eight items, along with the support structure, constitute the MRBT flow test stand; all other items necessary for the flow tests were part of the flow loop. The MRBT equipment is described in detail below, starting with item A in Figs. 2.1 and 2.2 and then following the upward water flow direction.

Water enters the test stand via a tee in the 10.16-cm-ID polyvinyl chloride (PVC) flow loop piping. The flow first encounters the lower transition section (item A in Figs. 2.1 and 2.2). One function of this transition section is to provide a structural support (visible on the right side of Fig. 2.2) for the bundle extensions (item C). This support is a 1.9-cm-thick Plexiglas disk with holes to accommodate the bundle extensions and to permit water flow. The support represents a 45% reduction in flow area compared with the flow area of the 10.16-cm-ID flow loop piping. The main function of the lower transition section is to provide a gradual hydraulic transition downstream of the structural support and into a rectangular flow channel with a bundle in the middle. This transition is achieved by means of four sloping inserts fastened to the inside of the lower transition section, which form a rectangular flow channel about the centrally located bundle extension.

The flow next enters one of two lower flow shrouds (Figs. 2.2 and 2.3; item B in both figures), which have channel dimensions appropriate for the two different upper shrouds (housing the burst bundles) used in the flow tests. Notice that four pressure taps are located at the same positions on both lower shrouds (two taps on each side). The two rightmost taps are used for pressure references, since measurements on the corresponding shroud sides are made directly against them. There are a few exceptions: the B-1/shroud 1* and some reference bundle/shroud 1* data were measured relative to atmospheric pressure.

These lower shrouds are 30.5 cm in length and were constructed from 1.9-cm-thick Plexiglas. They are bolted to the lower transition section with a neoprene gasket (having a cutout matching the rectangular flow channel) trapped between the two flanges. The bundle extension also passes through these lower shrouds and has a grid spacer (not shown on the data plots) roughly centered at the joint between the lower shroud and transition section. Adapters are fastened to the upper (left) end of the bundle extension to fit inside the burst and reference bundles. These adapters were centerless-ground to a diameter of 1.092 ± 0.005 cm

*In this context the diagonal (or solidus) means "in" — that is, "B-1/shroud 1" means "B-1 in shroud 1" and "reference bundle/shroud 1" means "reference bundle in shroud 1." This construction is used throughout this report.

to match the outside diameter of the Zircaloy cladding used to construct MRBT bundles and the bundle extension. The Inconel grid spacer is also from standard MRBT stock.

Summarizing, the flow enters the test stand through the support plate and passes into the lower transition section where the flow channel gradually becomes rectangular about a central bundle extension. The flow then enters the extension bundle/lower flow shroud assembly, which serves as a hydraulic entrance region.

Next, the water enters upper flow shrouds 1 and 2, shown in Figs. 2.4 and 2.5, respectively. Pressure taps are located on two sides of each shroud, the tap numbers decreasing in the flow direction. The shrouds are built in such a fashion that the sides with odd-number pressure taps are removable for easy insertion of the bundle for flow testing. The interface between the actual bundle and the bundle extension occurs roughly at the corresponding interface between the upper and lower shrouds. The differences between shrouds 1 and 2 are discussed next.

Design calculations indicated and experimental data confirmed that trade-offs exist pertaining to how much bypass flow area should be allowed between a bundle's periphery and the flow shroud walls. When axial pressure loss profiles for the burst bundle are compared with those for the reference bundle, the pressure loss differences between the two data sets should be made as large as possible to minimize uncertainties resulting from the precision limits of the data (this topic is discussed in depth in Chap. 3). This consideration favors a small bypass flow area. Hence, shroud 1 was originally built with a 6.35-cm by 6.35-cm channel, representing the smallest area the then unburst B-1 bundle could reasonably be construed to fit inside. However, after the B-1 burst test, flare-outs at the cladding rupture points required that three relief grooves be milled into the walls of shroud 1 and a thicker sealing gasket used to increase its flow channel area. A schematic of the modified shroud 1 flow channel, with the orientation of the B-1 and reference bundle tubes, is shown in Fig. 2.6. Figure 2.7 depicts the orientation of B-2 in shroud 1; Fig. 2.8 is a photograph of the three relief grooves in shroud 1.

It was recognized that shroud 1 might be too small to accommodate future burst bundles, and for this reason a second shroud with a larger flow channel was designed (shroud 2, shown in Figs. 2.5 and 2.9). The construction of shroud 2 was completed in time for the B-2 tests; hence, a direct comparison is possible between the sets of flow test data for the reference and B-2 bundles in both flow shrouds. Although B-2 was flow tested in shroud 2 without any shroud modifications being necessary, the resolution of increased B-2 pressure losses over those of the reference bundle is not as precise as for the comparable shroud 1 data. This undesirable feature is the result of pressure losses having the expected inverse square dependence on the flow channel area. Hence, there is a trade-off between fitting the burst bundles easily into the shrouds and minimizing the bypass flow (keeping the shrouds close fitting enough to ensure large pressure losses). If the pressure losses are not kept large, precision limitations on the data (due to instrumentation limits) can represent an intolerably large percentage of uncertainty.

A second trade-off also exists. The pressure taps cannot distinguish between reductions in the system pressure due to piezometric losses (the effects of friction, drag, and flow area lumped together for convenience into one term) and pressure reductions caused by diverted water flowing in a nonperpendicular fashion relative to the taps. Thus, it is imperative that the water velocity be parallel to the shroud walls (perpendicular to the pressure taps) so that the taps will be sensitive only to piezometric pressure effects. Otherwise, a mixture of piezometric and diverted-flow-induced pressure effects will be measured, which makes the mathematical modeling of such data extremely difficult. Hence, a significant bypass area between deformed bundles and the shroud walls ensures that any deformation-induced flow disturbances are dissipated and the flow is redirected parallel to the walls and is not impinging toward, or away from, the pressure taps.

The pressure tap holes for both shrouds were 0.159 cm in diameter through the 1.9-cm-thick shroud walls. Every effort was made to ensure that these tap holes were perpendicular to the shroud walls and that no rounded corners or burrs were present. The tap fittings were of the nylon Swagelok variety and were sealed to the shroud wall. Eighty taps were installed on the upper and lower shrouds — 40 taps on each side. These taps are located at matching locations on opposite walls for both shrouds; the axial spacing between taps for shroud 1 and shroud 2 differ slightly, however, due to improvements in the shroud 2 design.

Manifolds (item D in Fig. 2.1) were constructed to feed PVC pressure tap lines into the pressure tranducer ports via valves. With this arrangement it is possible to directly measure the pressure "seen" by any tap against that "seen" by another tap. Further, no static pressure head corrections were made, since both transducer pressure ports were always under the same effective column height of water no matter which two manifold valves were opened. This column is essentially the height of water in the upper transition section (F in Fig. 2.1) above the transducer ports, routed through the shroud, shroud taps, and into the two manifolds; hence, the same column height is always "seen" from both transducer ports because it is independent of manifold valve operation. The flow test procedures used in conducting these tests have been documented and are available in the MRBT files.

After leaving the upper flow shroud, the water flow is directed back into the flow loop piping via the upper transition section (see Fig. 2.10). This fitting is designed with a raised ring to seal against the MRBT bundle flange, the bundle passing through the central hole. One of the fitting's two arms is sealed with a blank flange, the discharge being directed through the other arm back into the loop. The bundle and upper transition assembly bolts onto the upper flow shrouds.

The jackscrew retaining mechanism (item G) may be seen in Fig. 2.1. This mechanism serves to prevent any upward shifting of the burst bundle tubes during the flow tests. Also, an adapter on the jackscrews provides a waterproof seal to protect against any water flowing up through the bursts in the tubes.

Figure 2.11 is a photograph of the reference bundle. The bundle rods were constructed of stainless steel rods centerless-ground to a 1.092 ± 0.005-cm diameter. They are mounted in a Plexiglas flange, and the spacing is maintained by three standard MRBT spacer grids to a 1.443 ± 0.010-cm square pitch. The placement of these grids matches the posttest B-1 and B-2 locations.

## 2.2 Differential Pressure Transducers

The following three transducers were used:

1. 0- to 25-kPa strain-gage transducer (BLH Electronics, Model No. 1100)
2. 0- to 75-kPa strain-gage transducer (BLH Electronics, Model No. 1300)
3. 0- to 200-kPa strain-gage transducer (BLH Electronics, Model No. 1800)

Endevco signal-conditioning and voltage-regulated bridge conditioner units (Models 4470 and 4471) were used in conjunction with these transducers. The transducer outputs were displayed on a Hewlett-Packard integrating digital voltmeter (Model 2401C), manually integrated over a 10-sec interval, and then hand recorded. The millivolt readings were then converted to kilopascal (kPa) units with transducer calibration curves and plotted via a computer program.

The transducers were checked against a water manometer before and after the flow tests for four or five reference pressures to ensure the integrity of their calibration curves. Data typical of these checks are given in Table 2.1. The upper pressure ranges of transducers 2 and 3 were not checked during the actual flow testing because they exceeded the maximum range of the manometer. However, recent full-range checks of these two transducers have confirmed the linearity of their pressure responses, as noted in Table 2.1. Pressure measurements made with the system herein described fall within a precision of about ±5%.

## 2.3 Turbine Meter

As stated earlier, a turbine meter (when operational and available) was located in the discharge line downstream of the MRBT test stand. A Flow Technology rotor and flow rate monitor (Model PRI-102FR), along with the previously described digital voltmeter, comprised the turbine meter instrumentation.

This assembly was checked against the upstream magnetic flow meter before and after each flow test to provide a precision estimate. Hence,

Table 2.1. Results from pressure transducer calibration checks

Numerical error limits represent one standard deviation of data used in the checks; percentage limits represent precision estimates

| Flow or calibration test description | BLH Electronics HLD transducer conversion factors (kPa/mV) | | |
|---|---|---|---|
| | Model 1100 | Model 1300 | Model 1800 |
| B-1 in shroud 1 | Unavailable | 2.082 ± 0.007 | 5.378 ± 0.069 |
| Reference bundle in shroud 1 | Unavailable | 2.082 ± 0.007 | 5.378 ± 0.069 |
| B-2 in shroud 1 | Unavailable | 2.068 ± 0.007 | 5.543 ± 0.021 |
| B-2 in shroud 1 | 0.807 ± 0.021[a] | 2.420 ± 0.014[a] | 6.385 ± 0.034[a] |
| Reference bundle in shroud 1 | 0.696 ± 0.007 | 2.082 ± 0.014 | 5.495 ± 0.034 |
| Grid test 1 (reference bundle in shroud 1) | 0.703 ± 0.007 | 2.089 ± 0.007 | 5.730 ± 0.048 |
| Grid test 2 (reference bundle in shroud 2) | 0.696 ± 0.007 | 2.096 ± 0.007 | 5.736 ± 0.076 |
| Calibration tests | 0.710 ± 0.007 | 2.110 ± 0.007 | 5.654 ± 0.028 |
| Average of above data | 0.699 ± 3% | 2.087 ± 2% | 5.551 ± 4% |

[a]These values are larger because a temporary circuit modification was used during this flow test; to make the values directly comparable, multiply by 0.861.

the turbine meter was primarily used as a precision check on the volumetric flow rate measurements, the magnetic flow meter being used to determine absolute magnitudes.

## 2.4 Magnetic Flow Meter

The determination of absolute volumetric flow rate constitutes the least-explored facet of the experimental data. Due to the fact that instrumentation for these tests was borrowed for a limited time only (as noted earlier), a Foxboro 9600 series magnetic flow meter was used to determine absolute volumetric flow rates without any calibration checks being conducted by MRBT personnel.

Precision estimates were made against the turbine meter, however, and were found to be in reasonable agreement with the ±1% precision limit at full scale (31.5 liters/sec) listed by the magnetic flow meter manufacturer. Over the volumetric flow rate range used for the flow tests, the precision limit, then, ranges from ±5% at 6.3 liters/sec to ±2% at 25.0 liters/sec. As pressure losses depend roughly on the square of the volumetric flow rate, these percentages reflect uncertainties of about ±10% (at lower flow rates) to ±5% (at higher flow rates) by which calculated and measured pressure profiles could conceivably differ.

Consequently, while reported volumetric flow rates and Reynolds number are very important to the reproducibility of the pressure loss measurements, only precision estimates are available (no data on absolute accuracy) for the reported flow rate data. There are two consolations concerning this matter, however: (1) the regular operators of the flow loop believe that the magnetic flow meter is within the manufacturer's tolerances, and (2) turbine meter checks tend to confirm that opinion.


Fig. 2.1. MRBT flow test stand: (A) lower transition section, (B) lower flow shroud, (C) bundle extension, (D) manifolds and connecting tubing, (E) upper flow shroud, (F) upper transition section, (G) jackscrew retaining mechanism.

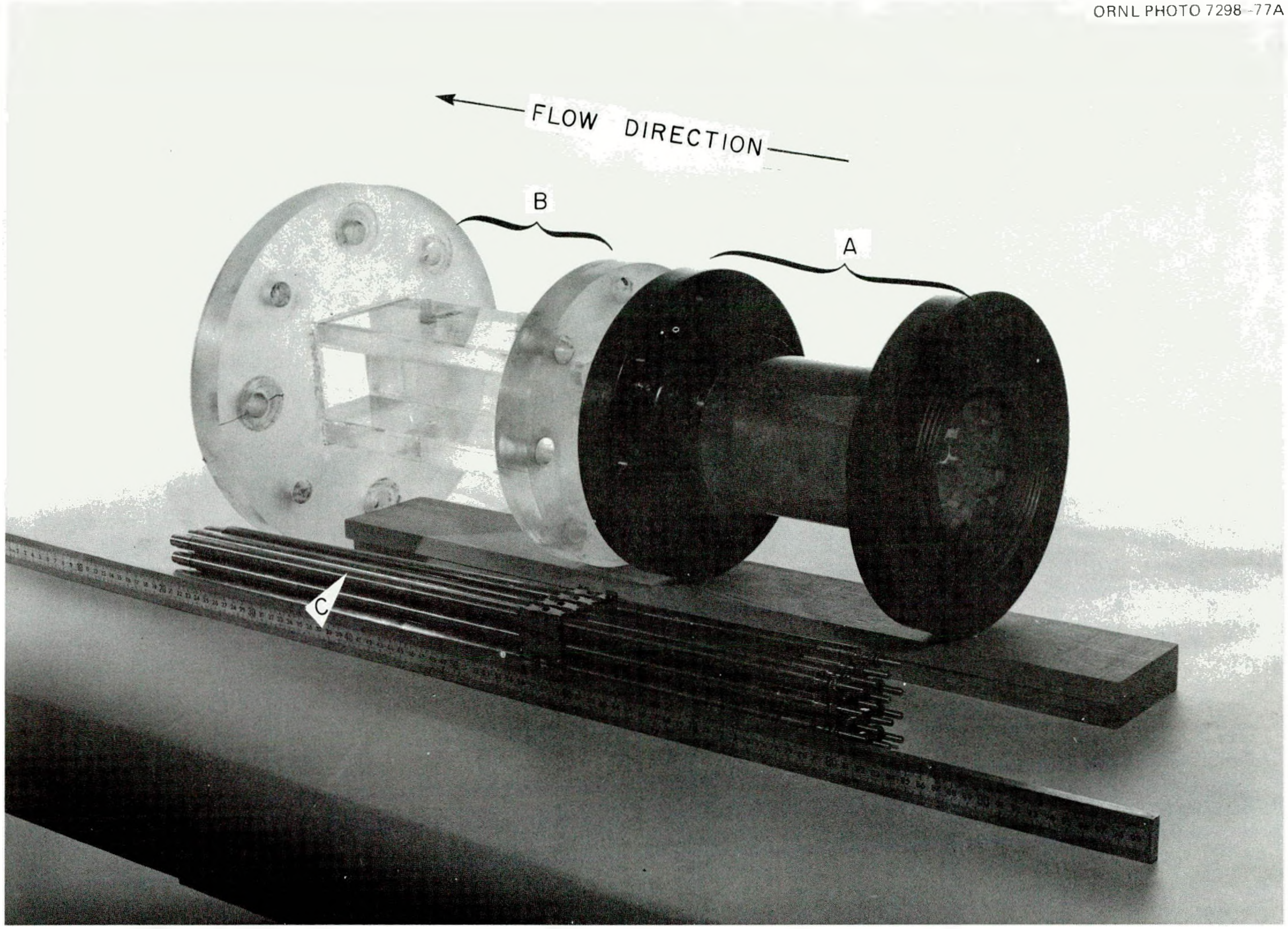



Fig. 2.2. Disassembled view of MRBT flow test stand: (A) lower transition section, (B) lower flow shroud 1, and (C) bundle extension.

ORNL PHOTO 7293 – 77A

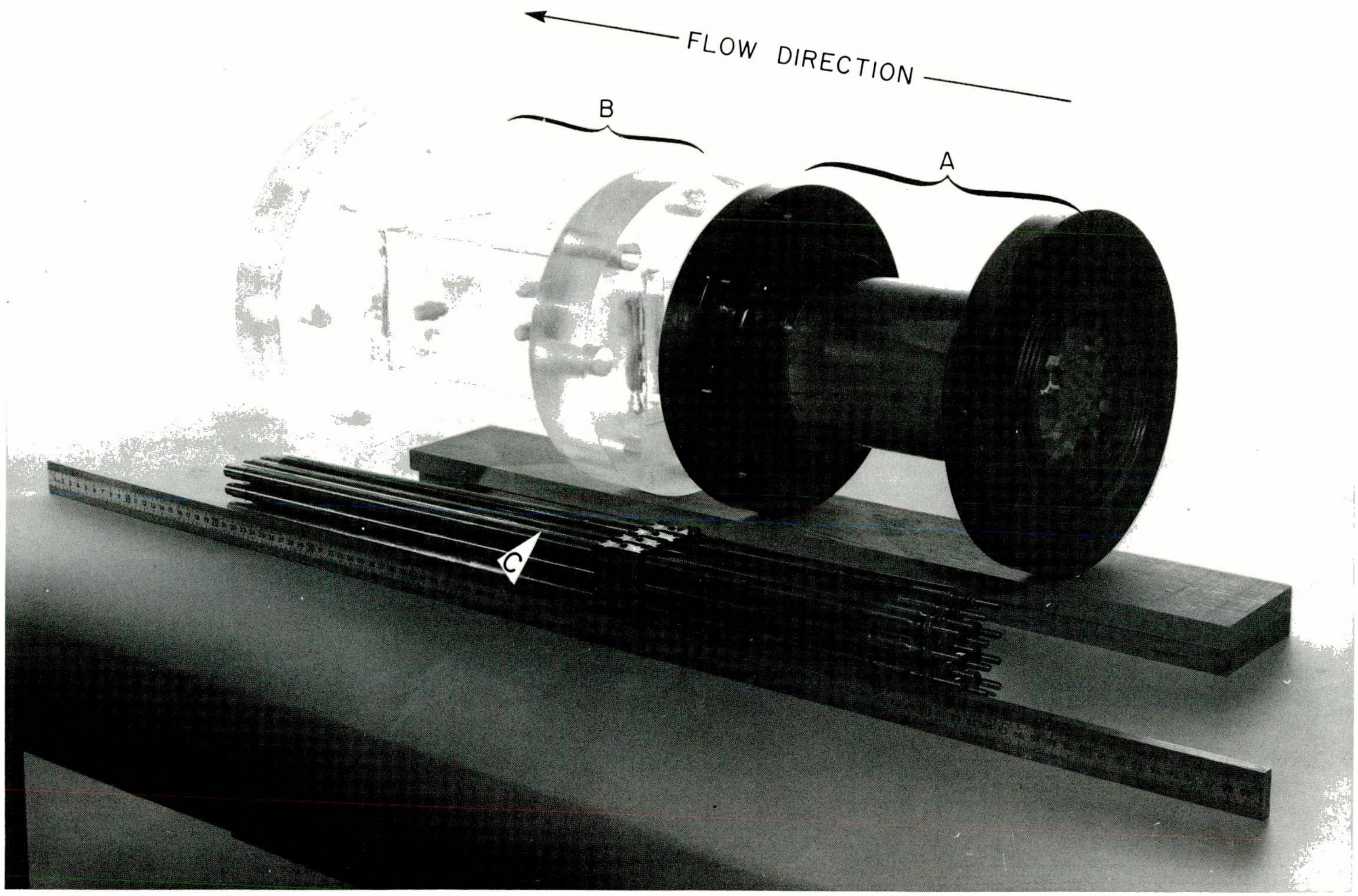



Fig. 2.3. Disassembled view of MRBT flow test stand: (A) lower transition section, (B) lower flow shroud 2, and (C) bundle extension.

ORNL PHOTO 7296-77A

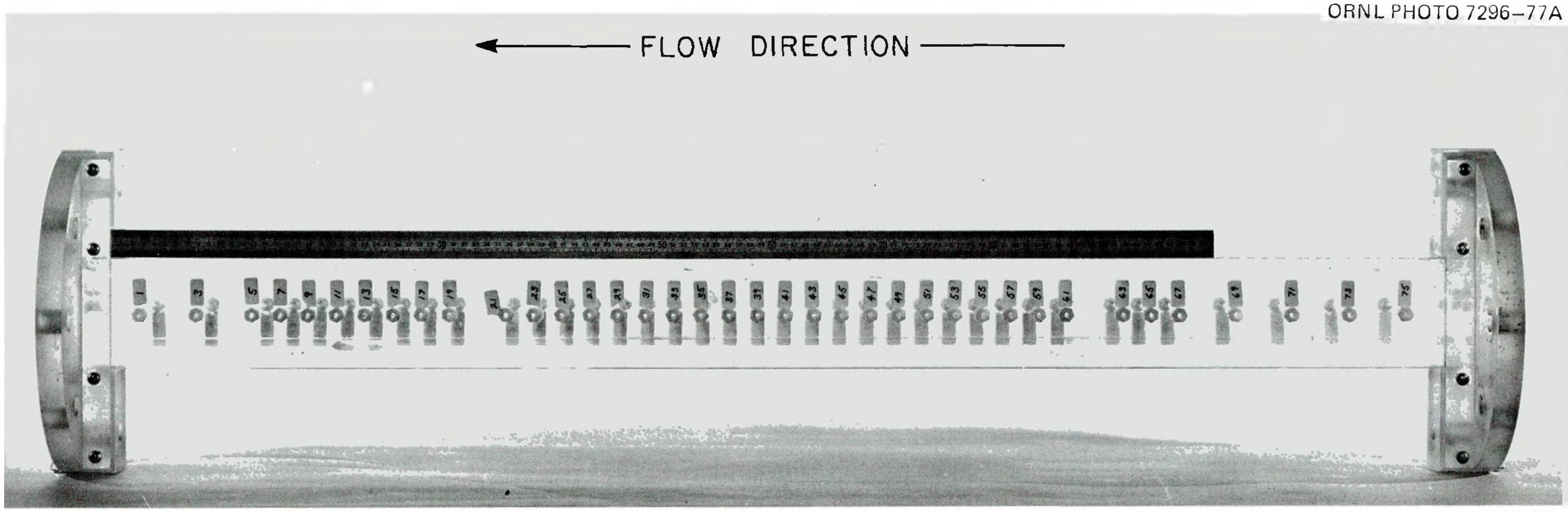



Fig. 2.4. Upper flow shroud 1.

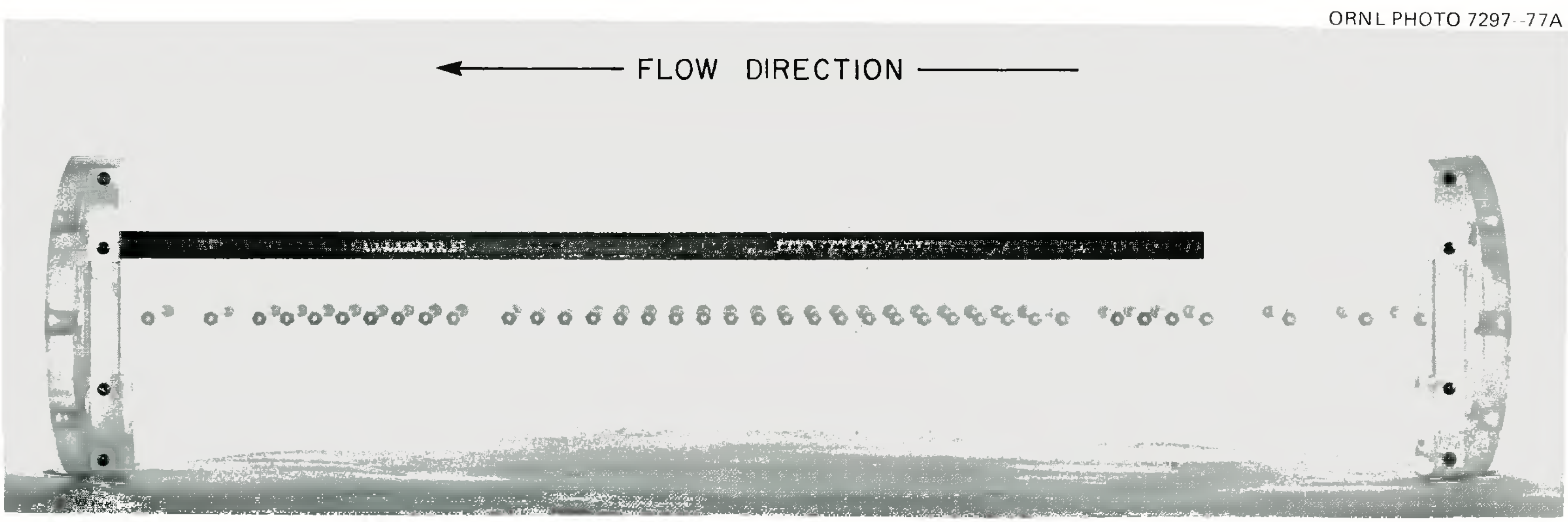
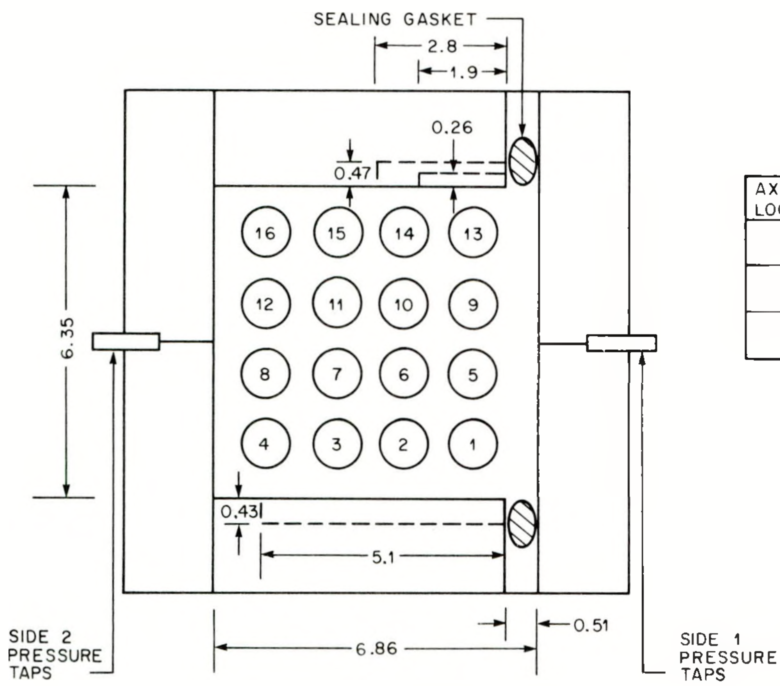



Fig. 2.5. Upper flow shroud 2.

ORNL-DWG 79-6454 ETD




AREA INFORMATION

UNDEFORMED BUNDLE AREA
= 14.99 ± 0.15 $cm^2$

UNDEFORMED WATER FLOW AREA
= 28.8 ± 0.5 $cm^2$

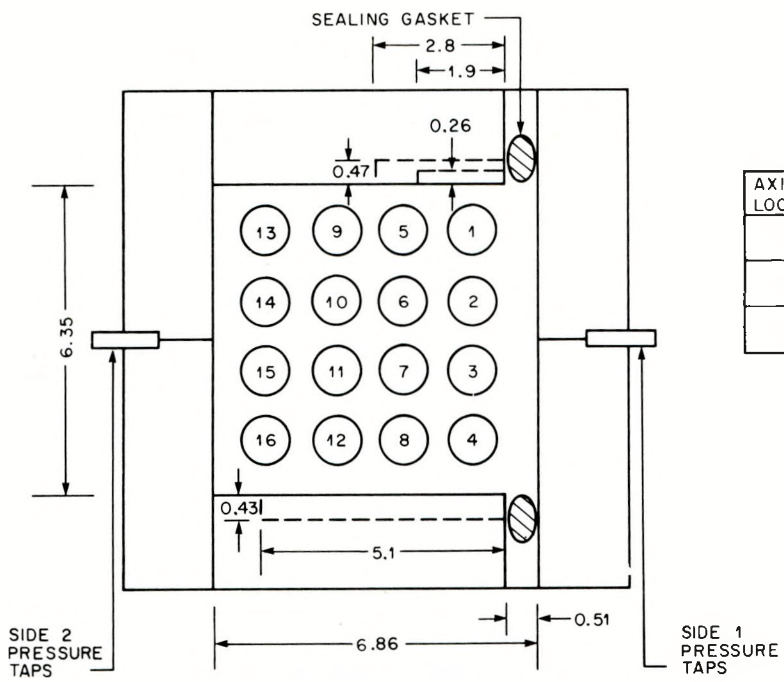
RELIEF GROOVES

| AXIAL B-1 LOCATION | WIDTH | DEPTH | LENGTH |
|---|---|---|---|
| 40.3 | 3.0 | 0.26 | 1.9 |
| 46.3 | 3.5 | 0.47 | 2.8 |
| 76.6 | 4.9 | 0.43 | 5.1 |

ALL DIMENSIONS IN CENTIMETERS

Fig. 2.6. General flow shroud 1 configuration with the reference bundle and B-1 present.

ORNL-DWG 79-6455 ETD




AREA INFORMATION

UNDEFORMED BUNDLE AREA
= 14.99 ± 0.15 $cm^2$

UNDEFORMED WATER FLOW AREA
= 28.8 ± 0.5 $cm^2$

RELIEF GROOVES

| AXIAL B-1 LOCATION | WIDTH | DEPTH | LENGTH |
|---|---|---|---|
| 40.3 | 3.0 | 0.26 | 1.9 |
| 46.3 | 3.5 | 0.47 | 2.8 |
| 76.6 | 4.9 | 0.43 | 5.1 |

ALL DIMENSIONS IN CENTIMETERS

Fig. 2.7. General flow shroud 1 configuration with B-2 present.

ORNL PHOTO 7294-77A


Fig. 2.8. View of the three relief grooves in upper shroud 1.

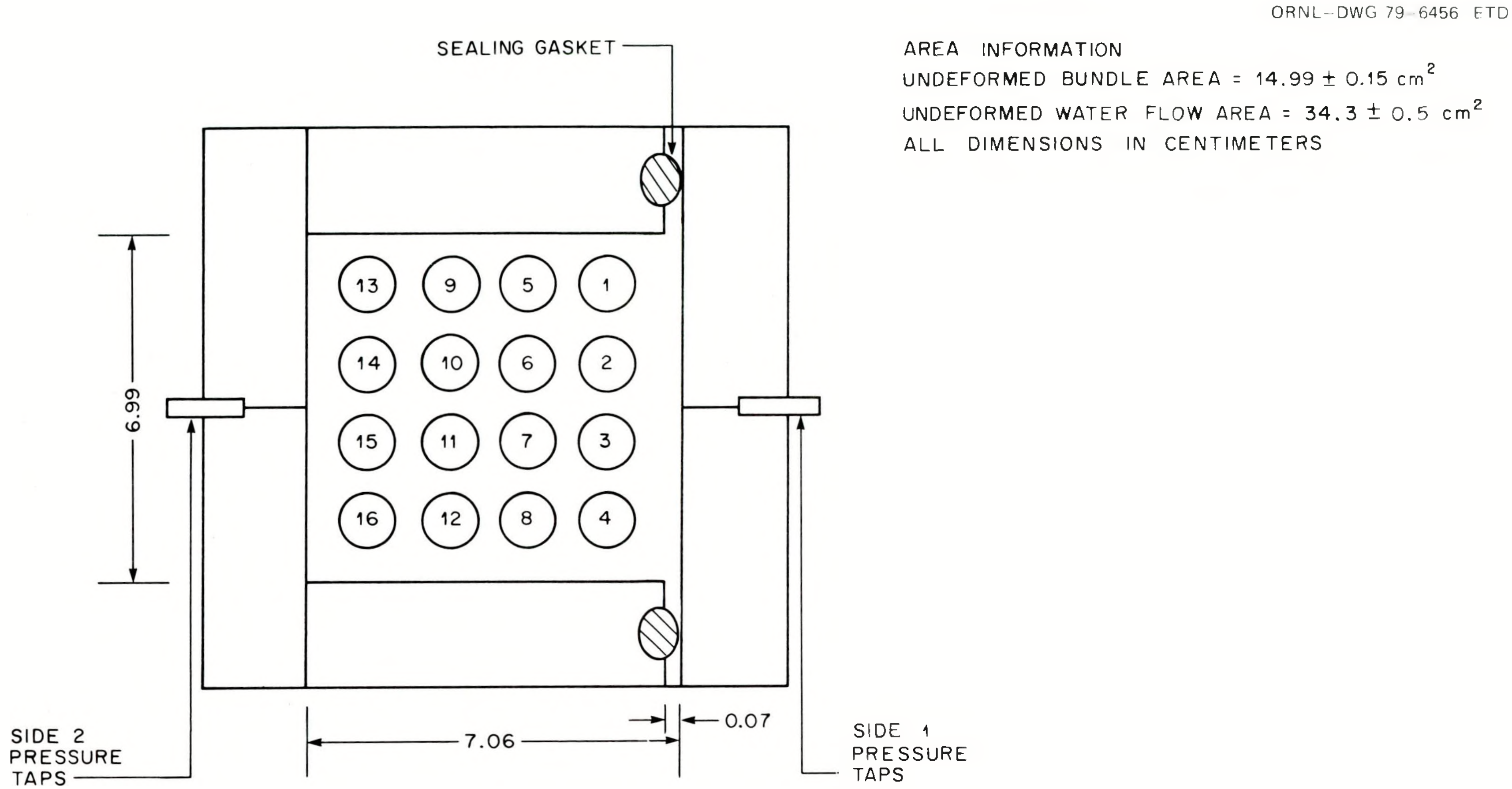



Fig. 2.9. General flow shroud 2 configuration with B-2 present.

ORNL PHOTO 7295--77A

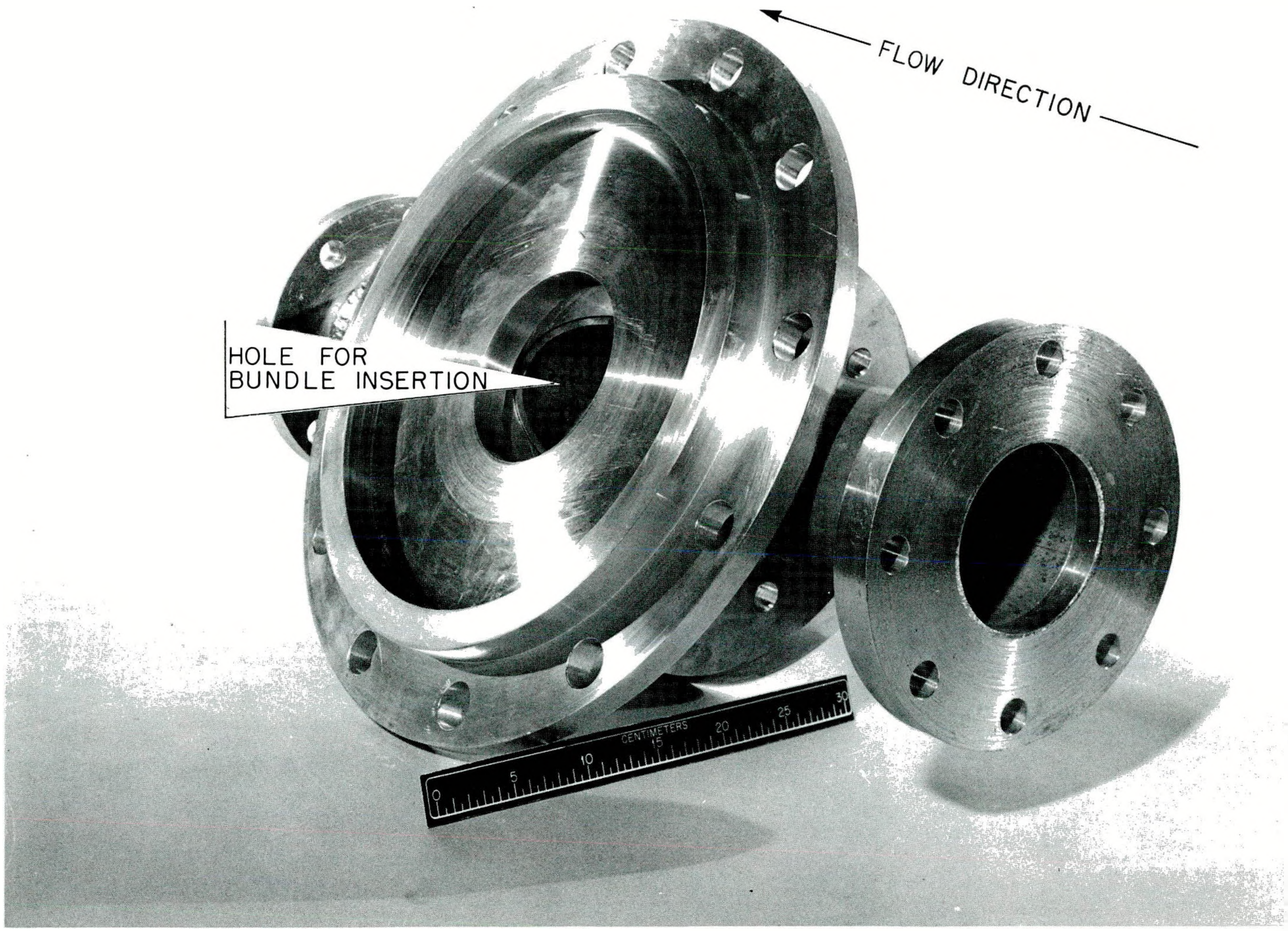



Fig. 2.10. Upper transition section.

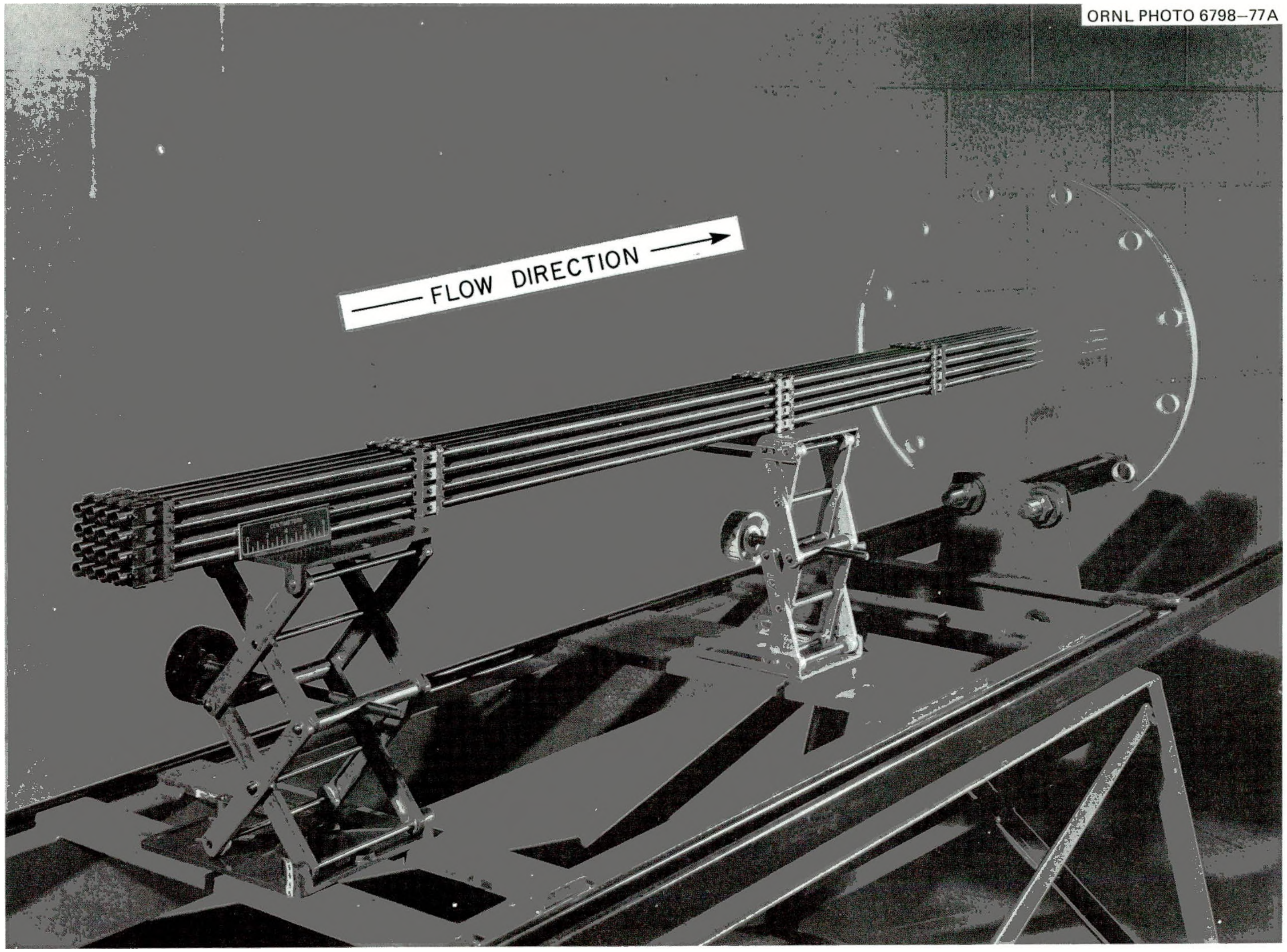



Fig. 2.11. Reference bundle for flow tests.

# 3. EXPERIMENTAL DATA

This chapter will deal mainly with the graphical presentation of experimental MRBT flow test data; the same data are available without interpretation in both graphical and tabulated formats in the MRBT B-1 and B-2 data reports.[3,4] Consequently, all comments made in this chapter on the mathematical modeling of such data will be of a qualitative nature, the details being deferred until Chaps. 4 and 5. The primary intent of this chapter is to provide the reader with some feeling for the precision to which these data are known.

Two general types of data plots were generated with the previously described procedures and equipment. The first type is concerned with the differential pressure loss performance (the pressure loss profile) along a bundle's axis for a fixed volumetric flow rate. In generating these data, differential pressure loss measurements were made directly against the two reference pressure taps, using both sets of wall-mounted taps during the flow tests. The two resulting sets of data may then be compared separately, against one another, or averaged together for comparison against similar sets of data generated with other bundles.

The second type of data plot displays the integrated pressure loss over the instrumented portion of the bundle/shroud assembly as a function of Reynolds number. This type of comparison provides some insight into how well the differential pressure loss measurements may be interpolated to other Reynolds numbers in the $3 \times 10^4 \leq Re \leq 2 \times 10^5$ flow regime. (It should be noted that this integrated pressure loss is the average differential loss measured between the uppermost and reference shroud taps.) A simplified representation of various friction factor correlations for this flow regime indicates that this functional dependence of pressure loss measurements on the Reynolds number is closely approximated for isothermal systems by:

$$\Delta P \propto (Re)^n , \qquad (3.1)$$

where n varies from about 1.7 to 1.8. Hence, by statistically fitting the data points in this second type of plot to such a power curve (and ignoring the details of the grid spacers' Reynolds-number-dependent contribution to the integrated pressure loss, $\Delta P_I$), additional insight is gained as to how well the data conform with existing empirical correlations (which suggest a Reynolds number, power-type dependence).

The Reynolds numbers used for these plots are averaged values in that the flow channel dimensions of the entire shroud were used in computing equivalent hydraulic diameters. The use of the adjective "maximum" in this context refers to the fact that this average Reynolds number is at a maximum in undeformed regions of the bundle, deformities increasing the wetted perimeter and hence lowering the Reynolds number for an isothermal, constant, volumetric flow rate. Such Reynolds numbers are referred to in the plots as "maximum Reynolds numbers" and are given to two significant figures, indicative of the precision to which they could be calculated with experimental flow channel dimensions, water temperature, and volumetric flow rate measurements.

## 3.1 First Single-Grid Tests in Shroud 1

Two series of flow tests were conducted with the reference bundle in shroud 1, using only one grid spacer at different locations in the instrumented portion of the reference bundle/shroud 1 assembly. The motivation for conducting these two experimental test series is to discriminate between pressure loss effects induced by friction in zones without spacer grids and those effects induced solely by the grids.

Results from the first single-grid test series begin with Figs. 3.1 to 3.6. The purpose of this series is to see what the pressure loss profile looks like for regions far away from grid spacers. Note that as the flow rate increases, two features emerge. First, a disturbance zone extends about 30 cm (20 hydraulic diameters) downstream of the spacer grid. Second, a significant nonlinearity exists in the pressure loss profile downstream of 65 cm. The persistence of these disturbed zones over several flow rates suggests these effects are real and not merely due to statistical error. The nonlinearity downstream of 65 cm is speculated to be induced by shroud exit effects and/or the third relief groove.

At one time some concern existed as to whether or not the three shroud 1 relief grooves (Figs. 2.6 to 2.8) adversely affected the flow tests. These grooves are located between 40 to 50 cm and 70 to 80 cm. For the 40- to 50-cm zone, some nonlinearities are visible but are relatively small and are considered of secondary importance when compared with data uncertainties. Hence, while the 70- to 80-cm relief groove zone roughly matches the location of the nonlinearity downstream of 65 cm, it is doubtful that the relief groove is solely responsible, since no similar effects of comparable magnitude appear in the 40- to 50-cm zone. Instead, shroud exit effects are suspected to have played the major role in producing this nonlinearity.

Figure 3.7 presents the average integrated pressure losses of this assembly as a function of Reynolds number. The power curve fit (solid line) was obtained using a standard linear regression analysis with the six data points shown on the plot. This power curve fit demonstrates the expected functional dependence of pressure loss measurements on the Reynolds number. Hence, interpolation of measured pressure losses to other Reynolds numbers in this range should be straightforward; extrapolations below or beyond this range must, of course, be subject to changes in the functional behavior of pressure losses with Reynolds number.

## 3.2 Second Single-Grid Tests in Shroud 1

A second flow test series, utilizing the same grid spacer further downstream, was conducted in shroud 1 to explicitly determine grid-spacer-induced pressure losses. These test results begin with Figs. 3.8 through 3.13 and are somewhat similar to those for the first single-grid tests. The actual modeling of grid-spacer-induced effects will be deferred until Chaps. 4 and 5.

Recalling that a zone of nonlinearity existed downstream of the grid in the first tests, it is somewhat surprising that the disturbed zone behind the grid in Figs. 3.8 to 3.13 is not as pronounced. Since the 40- to 50-cm relief groove zone also falls within the region, anomalies due to the two grooves and the grid are very small as any effects induced by them are not easily discernible.

Perhaps the most significant anomaly occurring in this set of plots is the separation of pressure tap measurements made on opposite sides of the shroud in Fig. 3.13. After measurements were made on one side of the shroud, a documented 4% flow rate variation occurred while the remainder of the data was being taken on the other side. A less-pronounced variation of the same type is suspected to have occurred while Fig. 3.12 data were being taken. Inasmuch as a 4% variation in the flow rate induces about a 7% variation in pressure losses (the flow test water temperature staying essentially constant) due to the $\Delta P \propto Re^n$ dependence, the anomalies in Figs. 3.12 and 3.13 are considered understood.

The sensitivity of such pressure loss measurements on other experimental parameters (e.g., flow rate variations) is a topic to consider carefully. In mathematically modeling such flow test data, one generally takes the reported flow rates, water temperature, and flow channel geometry data and tries to calculate the corresponding pressure loss profiles. In comparing these calculated and experimentally determined pressure loss profiles, there is a tendency to concentrate on how well two such profiles agree and to neglect the significance of flow rate or Reynolds number and flow area uncertainties. From Figs. 2.6, 2.7, and 2.9, the precision of the flow channel area determinations may be seen to be about 2%. The precision of the flow rate or Reynolds number determinations may be assumed to follow the behavior described in Sect. 2.3, ranging from ±5% at very low flow rates to ±2% at higher flow rates. Consequently, when an attempt is made to mathematically model the pressure profiles, portions of the calculated pressure profiles may conceivably be varied roughly on the order of ±10% due to the precision limits on the flow channel area and the flow rate or Reynolds number determinations [the $\pm 10\% = 1 - (1.05)^2$]. In addition, individual pressure measurements may be off by as much as ±5% of the reported values. Note that these comments are based solely on precision estimates; they do <u>not</u> reflect any systematic errors which might exist due to undetected instrument inaccuracies (e.g., the magnetic flow meter which MRBT personnel were unable to calibrate).

Figure 3.14 presents a plot of the average integrated pressure losses as a function of Reynolds number for this test series. The differences in the data fit correlations given in Figs. 3.7 and 3.14 result from the statistical nature of the technique used; both correlations can be shown to predict about the same values. The conclusions to be drawn are identical to those stated for Fig. 3.7. A discussion of the pressure loss characteristics of the grid spacer will be deferred until Chaps. 4 and 5.

## 3.3 Reference Bundle Tests in Shroud 1

A third series of flow tests was conducted with the reference bundle/shroud 1 assembly. Four standard MRBT Inconel grid spacers, placed at posttest B-1 grid locations, were used to determine undeformed pressure losses with the reference bundle. Data from this test series begin with Figs. 3.15 to 3.20. In these plots the disturbance zones behind the spacer grids are fairly visible (except for lower flow rates); the nonlinearity downstream of 65 cm is masked, however, by the grid spacer near that position. Overall, the data are reasonably good; the slopes between grids are relatively linear, and separation between the two pressure tap sets is minimal.

## 3.4 B-1 Tests in Shroud 1

Figures 3.21 to 3.24 are plots of differential pressure loss data taken with the B-1/shroud 1 assembly for four flow rates. Tables 3.1 and 3.2 list the B-1 deformed tube areas, using the minimum and maximum flow restriction definitions given in an earlier report.[5] Figures 3.25 to 3.28 represent averaged pressure loss profiles for B-1 (using the data in Figs 3.21 to 3.24) and the reference bundle against the overall B-1/shroud 1 flow restriction profiles (derived with minimum and maximum restriction data from Tables 3.1 and 3.2). By examining the behavior of the B-1 pressure loss profiles against the corresponding flow-channel-restriction profiles (in Figs. 3.25 to 3.28), one notices that the restriction profiles appear to be inverse, scaled-down representations of

Table 3.1. Lower limit of B-1 deformed tube areas (mm$^2$)

| Elevation (cm) | Tube No. | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | |
| 0.0 | 96 | 94 | 98 | 97 | 96 | 96 | 95 | 96 | 96 | 96 | 97 | 96 | 98 | 97 | 96 | 96 | 1549 |
| 1.8 | 104 | 109 | 108 | 109 | 105 | 113 | 108 | 109 | 109 | 111 | 105 | 109 | 111 | 109 | 110 | 105 | 1742 |
| 3.3 | 108 | 131 | 113 | 113 | 110 | 125 | 120 | 125 | 121 | 135 | 115 | 113 | 114 | 117 | 135 | 118 | 1919 |
| 5.2 | 108 | 129 | 108 | 114 | 109 | 119 | 121 | 128 | 123 | 130 | 120 | 111 | 110 | 119 | 150 | 118 | 1926 |
| 8.9 | 100 | 102 | 101 | 103 | 102 | 103 | 104 | 105 | 103 | 106 | 105 | 103 | 100 | 102 | 103 | 103 | 1651 |
| 11.8 | 102 | 104 | 101 | 104 | 103 | 105 | 105 | 107 | 103 | 106 | 107 | 104 | 101 | 102 | 105 | 103 | 1671 |
| 14.1 | 119 | 126 | 110 | 117 | 128 | 135 | 129 | 126 | 131 | 137 | 135 | 125 | 146 | 127 | 151 | 130 | 2080 |
| 15.4 | 117 | 124 | 114 | 119 | 144 | 137 | 128 | 125 | 134 | 140 | 135 | 125 | 175 | 132 | 174 | 139 | 2167 |
| 17.3 | 119 | 123 | 114 | 119 | 157 | 135 | 131 | 126 | 136 | 141 | 146 | 122 | 146 | 133 | 173 | 147 | 2175 |
| 18.8 | 124 | 130 | 112 | 124 | 149 | 140 | 135 | 131 | 153 | 149 | 195 | 121 | 127 | 146 | 179 | 153 | 2273 |
| 20.1 | 121 | 132 | 108 | 123 | 138 | 143 | 138 | 130 | 158 | 157 | 217 | 121 | 118 | 147 | 187 | 156 | 2301 |
| 20.6 | 121 | 132 | 108 | 122 | 136 | 142 | 137 | 128 | 157 | 156 | 215 | 118 | 116 | 142 | 180 | 154 | 2274 |
| 22.3 | 121 | 132 | 109 | 118 | 146 | 143 | 143 | 129 | 153 | 176 | 207 | 122 | 117 | 138 | 159 | 159 | 2279 |
| 23.9 | 120 | 134 | 111 | 117 | 151 | 140 | 146 | 130 | 154 | 195 | 195 | 127 | 121 | 141 | 153 | 179 | 2324 |
| 25.5 | 115 | 140 | 109 | 118 | 155 | 137 | 153 | 130 | 172 | 177 | 196 | 127 | 124 | 147 | 139 | 165 | 2312 |
| 26.5 | 116 | 144 | 110 | 120 | 172 | 144 | 158 | 127 | 177 | 175 | 190 | 126 | 129 | 150 | 133 | 151 | 2330 |
| 28.1 | 117 | 141 | 109 | 122 | 194 | 173 | 155 | 128 | 155 | 172 | 164 | 126 | 140 | 144 | 127 | 138 | 2311 |
| 29.7 | 116 | 136 | 109 | 117 | 170 | 190 | 146 | 129 | 140 | 153 | 141 | 123 | 146 | 135 | 126 | 133 | 2218 |
| 30.7 | 113 | 136 | 110 | 116 | 154 | 176 | 144 | 131 | 136 | 144 | 135 | 122 | 153 | 132 | 131 | 133 | 2173 |
| 33.2 | 109 | 136 | 109 | 112 | 141 | 145 | 152 | 137 | 130 | 137 | 133 | 128 | 133 | 130 | 139 | 128 | 2107 |
| 34.5 | 109 | 134 | 111 | 114 | 145 | 150 | 149 | 136 | 130 | 139 | 134 | 129 | 127 | 126 | 137 | 129 | 2108 |
| 36.6 | 110 | 130 | 113 | 117 | 147 | 143 | 145 | 141 | 125 | 134 | 136 | 125 | 127 | 128 | 133 | 140 | 2100 |
| 38.1 | 113 | 136 | 113 | 118 | 148 | 135 | 141 | 150 | 125 | 132 | 140 | 125 | 138 | 132 | 136 | 143 | 2131 |
| 39.7 | 124 | 144 | 109 | 117 | 149 | 132 | 141 | 156 | 133 | 134 | 141 | 130 | 221 | 143 | 139 | 139 | 2259 |
| 40.8 | 125 | 143 | 109 | 117 | 152 | 130 | 140 | 156 | 141 | 140 | 141 | 130 | 236 | 149 | 135 | 136 | 2288 |
| 42.9 | 119 | 138 | 112 | 120 | 169 | 125 | 138 | 170 | 163 | 143 | 134 | 136 | 150 | 156 | 133 | 137 | 2251 |
| 44.7 | 122 | 140 | 117 | 122 | 177 | 124 | 144 | 188 | 182 | 138 | 133 | 149 | 143 | 180 | 142 | 142 | 2352 |
| 46.7 | 123 | 139 | 113 | 124 | 188 | 124 | 156 | 171 | 193 | 137 | 134 | 162 | 155 | 187 | 147 | 134 | 2395 |
| 47.5 | 122 | 137 | 112 | 124 | 190 | 128 | 158 | 160 | 201 | 141 | 135 | 171 | 150 | 178 | 147 | 130 | 2391 |
| 48.6 | 119 | 133 | 118 | 125 | 176 | 126 | 151 | 153 | 180 | 140 | 130 | 176 | 143 | 161 | 142 | 132 | 2314 |
| 50.4 | 123 | 129 | 141 | 122 | 166 | 124 | 140 | 145 | 177 | 140 | 130 | 161 | 144 | 152 | 135 | 133 | 2270 |
| 52.4 | 130 | 131 | 113 | 116 | 148 | 123 | 137 | 143 | 175 | 141 | 131 | 142 | 143 | 148 | 135 | 128 | 2195 |
| 54.0 | 128 | 132 | 108 | 115 | 143 | 120 | 134 | 133 | 163 | 137 | 129 | 130 | 138 | 139 | 141 | 124 | 2121 |
| 55.6 | 120 | 125 | 106 | 115 | 149 | 117 | 129 | 131 | 153 | 132 | 126 | 124 | 128 | 129 | 137 | 122 | 2052 |
| 57.8 | 116 | 122 | 106 | 116 | 154 | 111 | 128 | 137 | 138 | 124 | 121 | 123 | 124 | 125 | 128 | 123 | 2004 |
| 60.1 | 122 | 123 | 105 | 123 | 135 | 109 | 141 | 130 | 132 | 123 | 121 | 116 | 126 | 129 | 124 | 114 | 1979 |
| 61.7 | 115 | 117 | 103 | 116 | 124 | 107 | 127 | 119 | 119 | 121 | 115 | 113 | 122 | 120 | 120 | 111 | 1875 |
| 64.1 | 100 | 101 | 97 | 101 | 104 | 98 | 102 | 102 | 101 | 102 | 101 | 101 | 103 | 102 | 103 | 102 | 1630 |
| 66.9 | 102 | 102 | 97 | 101 | 104 | 97 | 104 | 103 | 104 | 102 | 102 | 101 | 103 | 102 | 104 | 100 | 1636 |
| 68.8 | 124 | 118 | 103 | 117 | 136 | 102 | 126 | 117 | 121 | 120 | 120 | 117 | 117 | 118 | 120 | 113 | 1898 |
| 70.3 | 140 | 126 | 109 | 122 | 162 | 103 | 133 | 122 | 128 | 128 | 121 | 122 | 119 | 127 | 119 | 118 | 2006 |
| 72.7 | 147 | 139 | 112 | 127 | 192 | 102 | 149 | 128 | 145 | 128 | 124 | 122 | 119 | 142 | 126 | 120 | 2129 |
| 74.2 | 163 | 153 | 113 | 140 | 197 | 103 | 174 | 128 | 160 | 134 | 128 | 121 | 123 | 153 | 135 | 122 | 2254 |
| 76.5 | 172 | 159 | 113 | 173 | 196 | 103 | 172 | 125 | 147 | 135 | 126 | 131 | 136 | 150 | 137 | 127 | 2309 |
| 77.3 | 156 | 164 | 113 | 153 | 182 | 102 | 166 | 126 | 135 | 128 | 123 | 134 | 134 | 141 | 131 | 125 | 2221 |
| 80.2 | 147 | 161 | 111 | 137 | 149 | 104 | 143 | 130 | 140 | 125 | 128 | 129 | 137 | 141 | 130 | 119 | 2140 |
| 81.6 | 136 | 153 | 110 | 131 | 140 | 105 | 134 | 118 | 129 | 122 | 126 | 123 | 127 | 135 | 134 | 117 | 2047 |
| 83.5 | 132 | 152 | 109 | 120 | 142 | 108 | 128 | 114 | 130 | 122 | 124 | 122 | 129 | 129 | 137 | 119 | 2026 |
| 85.1 | 120 | 148 | 103 | 109 | 132 | 103 | 116 | 113 | 133 | 115 | 118 | 118 | 133 | 121 | 128 | 119 | 1935 |
| 86.5 | 118 | 129 | 101 | 105 | 119 | 101 | 110 | 111 | 133 | 114 | 116 | 115 | 132 | 114 | 119 | 115 | 1860 |
| 87.9 | 112 | 108 | 100 | 103 | 104 | 99 | 104 | 107 | 116 | 108 | 108 | 108 | 116 | 105 | 109 | 112 | 1726 |
| 90.0 | 102 | 98 | 96 | 100 | 97 | 96 | 99 | 98 | 96 | 98 | 99 | 94 | 96 | 98 | 101 | 100 | 1576 |
| 92.5 | 93 | 93 | 94 | 95 | 93 | 93 | 93 | 93 | 94 | 93 | 94 | 94 | 93 | 94 | 94 | 94 | 1503 |

Table 3.2. Upper limit of B-1 deformed tube areas ($mm^2$)

| Elevation (cm) | Tube No. | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | |
| 0.0 | 96 | 94 | 98 | 97 | 96 | 96 | 95 | 96 | 96 | 96 | 97 | 96 | 98 | 97 | 96 | 96 | 1549 |
| 1.8 | 104 | 109 | 108 | 109 | 105 | 113 | 108 | 109 | 109 | 111 | 105 | 109 | 111 | 109 | 110 | 105 | 1742 |
| 3.3 | 108 | 131 | 113 | 113 | 110 | 125 | 120 | 125 | 121 | 135 | 115 | 113 | 114 | 117 | 135 | 118 | 1919 |
| 5.2 | 108 | 129 | 108 | 114 | 109 | 119 | 121 | 128 | 123 | 130 | 120 | 111 | 110 | 119 | 150 | 118 | 1926 |
| 8.9 | 100 | 102 | 101 | 103 | 102 | 103 | 104 | 105 | 103 | 106 | 105 | 103 | 100 | 102 | 103 | 103 | 1651 |
| 11.8 | 102 | 104 | 101 | 104 | 103 | 105 | 105 | 107 | 103 | 106 | 107 | 104 | 101 | 102 | 105 | 103 | 1671 |
| 14.1 | 119 | 126 | 110 | 117 | 128 | 135 | 129 | 126 | 131 | 137 | 135 | 125 | 146 | 127 | 151 | 130 | 2080 |
| 15.4 | 117 | 124 | 114 | 119 | 144 | 137 | 128 | 125 | 134 | 140 | 135 | 125 | 175 | 132 | 174 | 139 | 2167 |
| 17.3 | 119 | 123 | 114 | 119 | 157 | 135 | 131 | 126 | 136 | 141 | 146 | 122 | 146 | 133 | 173 | 147 | 2175 |
| 18.8 | 124 | 130 | 112 | 124 | 149 | 140 | 135 | 131 | 153 | 149 | 195 | 121 | 127 | 146 | 179 | 153 | 2273 |
| 20.1 | 121 | 132 | 108 | 123 | 138 | 143 | 138 | 130 | 158 | 157 | 217 | 121 | 118 | 147 | 189 | 156 | 2303 |
| 20.6 | 121 | 132 | 108 | 122 | 136 | 142 | 137 | 128 | 157 | 156 | 215 | 118 | 116 | 142 | 180 | 154 | 2274 |
| 22.3 | 121 | 132 | 109 | 118 | 146 | 143 | 143 | 129 | 153 | 176 | 269 | 122 | 117 | 138 | 159 | 227 | 2409 |
| 23.9 | 120 | 134 | 111 | 117 | 151 | 140 | 146 | 130 | 154 | 209 | 217 | 127 | 121 | 141 | 153 | 283 | 2464 |
| 25.5 | 115 | 140 | 109 | 118 | 155 | 137 | 153 | 130 | 172 | 177 | 196 | 127 | 124 | 147 | 139 | 165 | 2312 |
| 26.5 | 116 | 144 | 110 | 120 | 172 | 144 | 158 | 127 | 177 | 175 | 190 | 126 | 129 | 150 | 133 | 151 | 2330 |
| 28.1 | 117 | 141 | 109 | 122 | 194 | 173 | 155 | 128 | 155 | 172 | 164 | 126 | 140 | 144 | 127 | 138 | 2311 |
| 29.7 | 116 | 136 | 109 | 117 | 170 | 253 | 146 | 129 | 140 | 153 | 141 | 123 | 146 | 135 | 126 | 133 | 2281 |
| 30.7 | 113 | 136 | 110 | 116 | 154 | 176 | 144 | 131 | 136 | 144 | 135 | 122 | 153 | 132 | 131 | 133 | 2173 |
| 33.2 | 109 | 136 | 109 | 112 | 141 | 145 | 152 | 137 | 130 | 137 | 133 | 128 | 133 | 130 | 139 | 128 | 2107 |
| 34.5 | 109 | 134 | 111 | 114 | 145 | 150 | 149 | 136 | 130 | 139 | 134 | 129 | 127 | 126 | 137 | 129 | 2108 |
| 36.6 | 110 | 130 | 113 | 117 | 147 | 143 | 145 | 141 | 125 | 134 | 136 | 125 | 127 | 128 | 133 | 140 | 2100 |
| 38.1 | 113 | 136 | 113 | 118 | 148 | 135 | 141 | 150 | 125 | 132 | 140 | 125 | 138 | 132 | 136 | 143 | 2131 |
| 39.7 | 124 | 144 | 109 | 117 | 149 | 132 | 141 | 156 | 133 | 134 | 141 | 130 | 221 | 143 | 139 | 139 | 2259 |
| 40.8 | 125 | 143 | 109 | 117 | 152 | 130 | 140 | 156 | 141 | 140 | 141 | 130 | 281 | 149 | 135 | 136 | 2333 |
| 42.9 | 119 | 138 | 112 | 120 | 169 | 125 | 138 | 170 | 163 | 143 | 134 | 136 | 150 | 156 | 133 | 137 | 2251 |
| 44.7 | 122 | 140 | 117 | 122 | 177 | 124 | 144 | 244 | 182 | 138 | 133 | 149 | 143 | 180 | 142 | 142 | 2409 |
| 46.7 | 123 | 139 | 113 | 124 | 188 | 124 | 156 | 171 | 291 | 137 | 134 | 162 | 155 | 262 | 147 | 134 | 2568 |
| 47.5 | 122 | 137 | 112 | 124 | 193 | 128 | 158 | 160 | 201 | 141 | 135 | 210 | 150 | 178 | 147 | 130 | 2433 |
| 48.6 | 119 | 133 | 118 | 125 | 176 | 126 | 151 | 153 | 180 | 140 | 130 | 222 | 143 | 161 | 142 | 132 | 2359 |
| 50.4 | 123 | 129 | 160 | 122 | 166 | 124 | 140 | 145 | 177 | 140 | 130 | 161 | 144 | 152 | 135 | 133 | 2289 |
| 52.4 | 130 | 131 | 113 | 116 | 148 | 123 | 137 | 143 | 175 | 141 | 131 | 142 | 143 | 148 | 135 | 128 | 2195 |
| 54.0 | 128 | 132 | 108 | 115 | 143 | 120 | 134 | 133 | 163 | 137 | 129 | 130 | 138 | 139 | 141 | 124 | 2121 |
| 55.6 | 120 | 125 | 106 | 115 | 149 | 117 | 129 | 131 | 153 | 132 | 126 | 124 | 128 | 129 | 137 | 122 | 2052 |
| 57.8 | 116 | 122 | 106 | 116 | 154 | 111 | 128 | 137 | 138 | 124 | 121 | 123 | 124 | 125 | 128 | 123 | 2004 |
| 60.1 | 122 | 123 | 105 | 123 | 135 | 109 | 141 | 130 | 132 | 123 | 121 | 116 | 126 | 129 | 124 | 114 | 1979 |
| 61.7 | 115 | 117 | 103 | 116 | 124 | 107 | 127 | 119 | 119 | 121 | 115 | 113 | 122 | 120 | 120 | 111 | 1875 |
| 64.1 | 100 | 101 | 97 | 101 | 104 | 98 | 102 | 102 | 101 | 102 | 101 | 101 | 103 | 102 | 103 | 102 | 1630 |
| 66.9 | 102 | 102 | 97 | 101 | 104 | 97 | 104 | 103 | 104 | 102 | 102 | 101 | 103 | 102 | 104 | 100 | 1636 |
| 68.8 | 124 | 118 | 103 | 117 | 136 | 102 | 126 | 117 | 121 | 120 | 120 | 117 | 117 | 118 | 120 | 113 | 1898 |
| 70.3 | 140 | 126 | 109 | 122 | 162 | 103 | 133 | 122 | 128 | 128 | 121 | 122 | 119 | 127 | 119 | 118 | 2006 |
| 72.7 | 147 | 139 | 112 | 127 | 192 | 102 | 149 | 128 | 145 | 128 | 124 | 122 | 119 | 142 | 126 | 120 | 2129 |
| 74.2 | 163 | 153 | 113 | 140 | 197 | 103 | 177 | 128 | 160 | 134 | 128 | 121 | 123 | 153 | 135 | 122 | 2257 |
| 76.5 | 243 | 181 | 113 | 258 | 196 | 103 | 225 | 125 | 147 | 135 | 126 | 131 | 136 | 150 | 137 | 127 | 2540 |
| 77.3 | 215 | 214 | 113 | 230 | 182 | 102 | 166 | 126 | 135 | 128 | 123 | 134 | 134 | 141 | 131 | 125 | 2406 |
| 80.2 | 147 | 161 | 111 | 137 | 149 | 104 | 143 | 130 | 140 | 125 | 128 | 129 | 137 | 141 | 130 | 119 | 2140 |
| 81.6 | 136 | 153 | 110 | 131 | 140 | 105 | 134 | 118 | 129 | 122 | 126 | 123 | 127 | 135 | 134 | 117 | 2047 |
| 83.5 | 132 | 152 | 109 | 120 | 142 | 108 | 128 | 114 | 130 | 122 | 124 | 122 | 129 | 129 | 137 | 119 | 2026 |
| 85.1 | 120 | 148 | 103 | 109 | 132 | 103 | 116 | 113 | 133 | 115 | 118 | 118 | 133 | 121 | 128 | 119 | 1935 |
| 86.5 | 118 | 129 | 101 | 105 | 119 | 101 | 110 | 111 | 133 | 114 | 116 | 115 | 132 | 114 | 119 | 115 | 1860 |
| 87.9 | 112 | 108 | 100 | 103 | 104 | 99 | 104 | 107 | 116 | 108 | 108 | 108 | 116 | 105 | 109 | 112 | 1726 |
| 90.0 | 102 | 98 | 96 | 100 | 97 | 96 | 99 | 98 | 96 | 98 | 99 | 94 | 96 | 98 | 101 | 100 | 1576 |
| 92.5 | 93 | 93 | 94 | 95 | 93 | 93 | 93 | 93 | 94 | 93 | 94 | 94 | 93 | 94 | 94 | 94 | 1503 |

the pressure loss profiles, neither restriction definition being obviously more representative.

Figures 3.21 to 3.28 suggest that several generalizations may be made about burst bundle experimental data. With the exception of a few data points, the two sets of differential pressure loss profiles taken on opposing sides of the B-1/shroud 1 assembly appear to be equivalent within the data precision limits (see Figs. 3.21 to 3.24). Further, by a somewhat tedious comparison with Tables 3.1 and 3.2, it may be observed that the axial points at which differences between opposing pressure measurements appear (outside experimental uncertainty limits) are generally covariant with the occurrence of larger tube areas along only one shroud wall which houses a set of pressure taps. Hence, while localized pressure profile features may be induced by deformed tubes close to the pressure taps, the general shape of the pressure loss profiles is primarily dependent upon the gross axial-flow-area behavior of the burst bundle/shroud assembly. By averaging the two differential profiles together for each flow test (as in Figs. 3.25 to 3.28), a fairly good approximation to the bundle-averaged pressure loss profile may be derived from this experimental data.

These overlain averaged pressure loss profiles also provide a visual comparison between B-1 and reference bundle pressure losses as a function of axial position. Caution must be taken, however, in the resolution of B-1 deformation-induced losses over the pressure losses of an undeformed bundle. The effect of precision limitations on comparisons between two such sets of data is important yet subtle. In Fig. 3.25, the B-1 and reference bundle profiles are essentially the same below 0 cm; similarly, the water temperature for the two tests is about the same (24°C). Yet the B-1/reference bundle flow rate ratio is about 0.93, implying that the B-1 pressure profile should be uniformly lower, by about a factor of 14%, than that of the reference bundle under these conditions. This anomaly is indicative of the precision to which flow rates and Reynolds numbers could be calculated for these tests (i.e., the profiles might indeed agree below 0 cm if the reported B-1 flow rate was higher by 3.5% and the reference bundle flow rate lower by 3.5%). Consequently, uncertainties in the determination of deformation-induced pressure losses and the normal pressure losses an unburst bundle would experience are rather severe due to existing Reynolds number and pressure measurement precision limits.

The following scenario illustrates the previous discussion. Since the pressure loss profiles in Fig. 3.25 agree below 0 cm despite flow rate or Reynolds number differences, some assumptions must be made to determine the increased nonrecoverable B-1 losses due to bundle deformation over the normal, permanent losses of an unburst bundle. First, assume that the flow channel geometries are identical below 0 cm and water temperatures are the same for both bundles. Now two sources of uncertainty exist: uncertainties in flow rate or Reynolds number determinations and in pressure measurements. These assumptions and the agreement of the pressure loss profiles below 0 cm imply the same flow rate for both tests. If an average is taken to determine a Reynolds number corresponding to both profiles, no flow-rate-type corrections need be made to the two pressure loss profiles. At 96 cm, the B-1 data point is 17.2 kPa; for reference bundle, it is 12.1 kPa. Assume that the ±5% precision limit on differential pressure measurements mentioned in Sect. 2.2 applies to these values. Hence, the uncertainty for the 17.2-kPa measurement is ±0.9 kPa, and that for 12.1 kPa is ±0.6 kPa. The difference between the B-1 and reference pressures at 96 cm is then 5.1 ± 1.1 kPa, or ±22% for a Reynolds number of $3.5 \pm 0.3 \times 10^4$. Further, if one desires to compare such experimentally derived deformation-induced pressure differences with their calculational counterparts, the effects of flow rate uncertainties (i.e., the $\pm 0.3 \times 10^4$) on such comparisons must be considered. While the preceding is admittedly an extreme scenario (the precision limits on these two particular measurements may well be ±2 or ±3% instead of ±5%), the point must be strongly made that uncertainties in the flow test data severely limit how precisely deformation-induced pressure losses between burst and reference bundle pressure loss profiles may be resolved.

Figures 3.26, 3.27, and 3.28 give B-1 to reference bundle flow rate ratios of 1.02, 1.01, and 1.00, respectively (because of comparable fluid temperatures, the corresponding Reynolds number ratios are the same). Notice that the agreement of the two profiles below 0 cm generally improves with increasing flow rate magnitudes. This tendency, along with the discrepancy discussed for Fig. 3.25, is indicative of the fact that the larger flow rates and Reynolds numbers are known more precisely on a percentage basis.

By an examination of Figs. 3.25 through 3.28, an estimation of the permanent pressure losses induced by the three deformation zones (12 to 32 cm, 38 to 63 cm, and 68 to 96 cm) may be obtained in terms of losses induced by a spacer grid. Bundle deformities induce two types of pressure losses: a permanent nonrecoverable loss and a nonpermanent loss which is recovered shortly downstream of the restriction. At 96 cm in Figs. 3.25 through 3.28, virtually all of the difference in pressure between the B-1 and reference bundle profiles results from permanent losses induced by B-1 deformities. If this pressure difference is divided by 3 (for the three burst zones) and then by the permanent loss associated with a spacer grid, these B-1 deformation zones are seen to have permanent losses of about 1 1/2 times those typical of MRBT grid spacers for this flow regime.

Figure 3.29 presents average integrated pressure loss measurements as a function of Reynolds number for the B-1 and reference bundles in shroud 1. As seen, these two sets of pressure data follow the expected functional dependence on the Reynolds number.

## 3.5 B-2 Tests in Shroud 1

Figures 3.30 to 3.33 are plots of differential pressure loss data taken with the B-2/shroud 1 assembly for four flow rates. Tables 3.3 and 3.4 list B-2 deformed tube areas based on the minimum and maximum flow restriction definitions. Figures 3.34 to 3.37 compare averaged B-2 and reference bundle differential pressure loss profiles against the fractional flow restriction profiles for the B-2/shroud 1 assembly.

Note (in Figs. 3.30 to 3.33) that, as for the similar set of B-1 plots, pressure measurements made on opposing shroud walls tend to agree

Table 3.3. Lower limit of B-2 deformed tube areas ($mm^2$)

| Elevation (cm) | Tube No. | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | TOTAL |
| 0.0 | 93 | 93 | 93 | 94 | 93 | 92 | 93 | 94 | 92 | 92 | 92 | 93 | 91 | 92 | 92 | 93 | 1490 |
| 1.8 | 102 | 104 | 105 | 104 | 101 | 107 | 107 | 106 | 102 | 103 | 103 | 107 | 101 | 105 | 102 | 102 | 1670 |
| 3.4 | 114 | 115 | 117 | 114 | 114 | 132 | 121 | 116 | 109 | 114 | 115 | 119 | 111 | 123 | 112 | 108 | 1862 |
| 5.0 | 114 | 116 | 115 | 116 | 113 | 128 | 119 | 115 | 110 | 114 | 115 | 115 | 111 | 119 | 114 | 109 | 1850 |
| 6.9 | 110 | 112 | 109 | 108 | 108 | 120 | 114 | 108 | 107 | 111 | 111 | 110 | 107 | 112 | 108 | 106 | 1767 |
| 8.8 | 102 | 103 | 101 | 101 | 100 | 103 | 101 | 101 | 99 | 99 | 101 | 100 | 100 | 100 | 99 | 99 | 1616 |
| 11.5 | 100 | 101 | 101 | 102 | 100 | 104 | 101 | 102 | 100 | 100 | 102 | 102 | 100 | 101 | 99 | 101 | 1622 |
| 13.3 | 110 | 108 | 111 | 108 | 106 | 123 | 117 | 112 | 111 | 112 | 119 | 114 | 109 | 113 | 103 | 106 | 1791 |
| 15.1 | 120 | 116 | 116 | 112 | 110 | 136 | 124 | 119 | 114 | 118 | 127 | 125 | 116 | 128 | 106 | 107 | 1902 |
| 16.8 | 124 | 126 | 122 | 116 | 116 | 141 | 125 | 126 | 115 | 126 | 131 | 129 | 122 | 154 | 115 | 114 | 2009 |
| 18.1 | 125 | 130 | 129 | 119 | 122 | 142 | 125 | 131 | 115 | 127 | 128 | 130 | 125 | 177 | 118 | 116 | 2065 |
| 19.5 | 133 | 133 | 134 | 121 | 131 | 140 | 130 | 137 | 123 | 138 | 127 | 136 | 136 | 188 | 118 | 119 | 2150 |
| 21.4 | 134 | 129 | 134 | 114 | 130 | 138 | 130 | 141 | 121 | 140 | 124 | 145 | 133 | 164 | 115 | 117 | 2115 |
| 23.2 | 133 | 126 | 138 | 112 | 131 | 145 | 131 | 151 | 123 | 142 | 123 | 139 | 131 | 148 | 119 | 120 | 2118 |
| 25.0 | 126 | 121 | 144 | 115 | 129 | 142 | 137 | 152 | 124 | 137 | 120 | 131 | 126 | 140 | 124 | 123 | 2096 |
| 26.9 | 124 | 116 | 148 | 120 | 122 | 134 | 142 | 136 | 122 | 137 | 120 | 132 | 123 | 125 | 128 | 117 | 2054 |
| 28.5 | 127 | 118 | 157 | 127 | 123 | 137 | 145 | 129 | 123 | 143 | 122 | 133 | 123 | 124 | 131 | 114 | 2083 |
| 30.0 | 123 | 118 | 164 | 131 | 123 | 138 | 142 | 126 | 120 | 142 | 124 | 132 | 118 | 125 | 129 | 116 | 2076 |
| 32.0 | 118 | 124 | 153 | 134 | 123 | 136 | 138 | 126 | 120 | 137 | 122 | 135 | 119 | 128 | 121 | 120 | 2060 |
| 34.0 | 116 | 124 | 139 | 129 | 123 | 143 | 133 | 123 | 121 | 131 | 123 | 136 | 126 | 129 | 119 | 119 | 2042 |
| 35.9 | 119 | 130 | 138 | 121 | 124 | 194 | 129 | 126 | 120 | 134 | 127 | 130 | 127 | 140 | 121 | 116 | 2105 |
| 37.7 | 120 | 131 | 143 | 120 | 130 | 233 | 125 | 136 | 123 | 146 | 126 | 124 | 122 | 158 | 126 | 118 | 2190 |
| 39.5 | 117 | 123 | 135 | 121 | 125 | 182 | 131 | 142 | 120 | 164 | 122 | 122 | 118 | 155 | 125 | 120 | 2128 |
| 41.2 | 132 | 125 | 143 | 125 | 126 | 171 | 141 | 157 | 126 | 191 | 127 | 132 | 129 | 150 | 128 | 127 | 2237 |
| 43.3 | 139 | 125 | 156 | 128 | 125 | 194 | 133 | 177 | 122 | 165 | 127 | 137 | 128 | 137 | 124 | 131 | 2256 |
| 44.7 | 142 | 123 | 177 | 131 | 123 | 185 | 128 | 165 | 122 | 151 | 126 | 131 | 125 | 132 | 119 | 138 | 2225 |
| 46.2 | 152 | 128 | 179 | 134 | 126 | 174 | 128 | 142 | 128 | 142 | 126 | 130 | 123 | 130 | 117 | 155 | 2218 |
| 47.7 | 169 | 132 | 160 | 134 | 132 | 176 | 135 | 130 | 137 | 145 | 129 | 132 | 125 | 131 | 120 | 160 | 2253 |
| 49.7 | 155 | 133 | 138 | 132 | 136 | 170 | 136 | 129 | 132 | 135 | 134 | 135 | 122 | 133 | 127 | 139 | 2196 |
| 51.6 | 136 | 134 | 126 | 142 | 151 | 155 | 128 | 131 | 129 | 136 | 131 | 139 | 122 | 136 | 129 | 133 | 2166 |
| 53.5 | 130 | 134 | 133 | 156 | 170 | 148 | 134 | 129 | 133 | 138 | 130 | 147 | 139 | 142 | 136 | 153 | 2261 |
| 54.9 | 132 | 139 | 133 | 151 | 155 | 148 | 140 | 129 | 130 | 140 | 129 | 151 | 158 | 144 | 135 | 175 | 2296 |
| 56.2 | 136 | 146 | 137 | 151 | 146 | 147 | 143 | 139 | 129 | 145 | 129 | 153 | 187 | 152 | 142 | 188 | 2378 |
| 57.6 | 128 | 140 | 138 | 153 | 138 | 137 | 133 | 144 | 123 | 138 | 120 | 142 | 169 | 146 | 135 | 164 | 2254 |
| 59.8 | 120 | 123 | 131 | 143 | 123 | 129 | 127 | 127 | 119 | 128 | 115 | 129 | 126 | 130 | 121 | 128 | 2027 |
| 61.8 | 115 | 113 | 118 | 118 | 114 | 120 | 123 | 117 | 115 | 120 | 114 | 121 | 119 | 117 | 114 | 114 | 1881 |
| 63.8 | 103 | 103 | 103 | 105 | 103 | 104 | 104 | 105 | 100 | 103 | 103 | 104 | 105 | 104 | 103 | 105 | 1665 |
| 66.5 | 102 | 102 | 103 | 106 | 102 | 104 | 105 | 104 | 101 | 103 | 104 | 103 | 104 | 103 | 101 | 103 | 1658 |
| 68.4 | 113 | 115 | 120 | 114 | 115 | 129 | 130 | 116 | 118 | 121 | 123 | 115 | 115 | 114 | 109 | 111 | 1886 |
| 70.1 | 123 | 130 | 134 | 125 | 126 | 151 | 141 | 127 | 128 | 129 | 136 | 127 | 112 | 132 | 118 | 118 | 2065 |
| 71.6 | 123 | 139 | 137 | 138 | 136 | 151 | 138 | 129 | 133 | 130 | 135 | 127 | 112 | 148 | 119 | 122 | 2124 |
| 73.1 | 126 | 146 | 145 | 159 | 139 | 147 | 141 | 133 | 141 | 131 | 136 | 129 | 114 | 150 | 120 | 129 | 2195 |
| 74.6 | 138 | 165 | 174 | 177 | 142 | 159 | 152 | 139 | 156 | 139 | 149 | 134 | 127 | 145 | 128 | 135 | 2366 |
| 76.2 | 142 | 179 | 184 | 188 | 139 | 171 | 162 | 139 | 143 | 146 | 168 | 141 | 128 | 140 | 139 | 140 | 2459 |
| 78.0 | 144 | 155 | 166 | 166 | 143 | 155 | 168 | 139 | 135 | 152 | 183 | 149 | 128 | 141 | 161 | 141 | 2432 |
| 79.5 | 141 | 136 | 140 | 151 | 143 | 140 | 182 | 138 | 134 | 153 | 170 | 156 | 127 | 139 | 170 | 139 | 2366 |
| 81.6 | 128 | 130 | 127 | 149 | 132 | 143 | 226 | 126 | 132 | 154 | 148 | 182 | 122 | 131 | 146 | 126 | 2311 |
| 83.8 | 116 | 125 | 125 | 132 | 121 | 143 | 164 | 119 | 126 | 137 | 135 | 138 | 114 | 126 | 122 | 116 | 2066 |
| 86.0 | 109 | 121 | 118 | 119 | 124 | 123 | 136 | 116 | 121 | 141 | 122 | 117 | 108 | 122 | 112 | 114 | 1930 |
| 88.1 | 106 | 109 | 105 | 108 | 113 | 111 | 117 | 109 | 108 | 117 | 108 | 107 | 103 | 112 | 106 | 109 | 1758 |
| 89.9 | 95 | 96 | 96 | 99 | 97 | 97 | 98 | 95 | 96 | 100 | 94 | 99 | 93 | 98 | 94 | 95 | 1550 |
| 91.5 | 94 | 94 | 95 | 95 | 95 | 93 | 95 | 93 | 94 | 96 | 94 | 95 | 93 | 96 | 94 | 94 | 1518 |

Table 3.4. Upper limit of B-2 deformed tube areas ($mm^2$)

| Elevation (cm) | Tube No. | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | TOTAL |
| 0.0 | 93 | 93 | 93 | 94 | 93 | 92 | 93 | 94 | 92 | 92 | 92 | 93 | 91 | 92 | 92 | 93 | 1490 |
| 1.8 | 102 | 104 | 105 | 104 | 101 | 107 | 107 | 106 | 102 | 103 | 103 | 107 | 101 | 105 | 102 | 102 | 1670 |
| 3.4 | 114 | 115 | 117 | 114 | 114 | 132 | 121 | 116 | 109 | 114 | 115 | 119 | 111 | 123 | 112 | 108 | 1862 |
| 5.0 | 114 | 116 | 115 | 116 | 113 | 128 | 119 | 115 | 110 | 114 | 115 | 115 | 111 | 119 | 114 | 109 | 1850 |
| 6.9 | 110 | 112 | 109 | 108 | 108 | 120 | 114 | 108 | 107 | 111 | 111 | 110 | 107 | 112 | 108 | 106 | 1767 |
| 8.8 | 102 | 103 | 101 | 101 | 100 | 103 | 101 | 101 | 99 | 99 | 101 | 100 | 100 | 100 | 99 | 99 | 1616 |
| 11.5 | 100 | 101 | 101 | 102 | 100 | 104 | 101 | 102 | 100 | 100 | 102 | 102 | 100 | 101 | 99 | 101 | 1622 |
| 13.3 | 110 | 108 | 111 | 108 | 106 | 123 | 117 | 112 | 111 | 112 | 119 | 114 | 109 | 113 | 103 | 106 | 1791 |
| 15.1 | 120 | 116 | 116 | 112 | 110 | 136 | 124 | 119 | 114 | 118 | 127 | 125 | 116 | 128 | 106 | 107 | 1902 |
| 16.8 | 124 | 126 | 122 | 116 | 116 | 141 | 125 | 126 | 115 | 126 | 131 | 129 | 122 | 154 | 115 | 114 | 2009 |
| 18.1 | 125 | 130 | 129 | 119 | 122 | 142 | 125 | 131 | 115 | 127 | 128 | 130 | 125 | 177 | 118 | 116 | 2065 |
| 19.5 | 133 | 133 | 134 | 121 | 131 | 140 | 130 | 137 | 123 | 138 | 127 | 136 | 136 | 233 | 118 | 119 | 2195 |
| 21.4 | 134 | 129 | 134 | 114 | 130 | 138 | 130 | 141 | 121 | 140 | 124 | 145 | 133 | 164 | 115 | 117 | 2115 |
| 23.2 | 133 | 126 | 138 | 112 | 131 | 145 | 131 | 151 | 123 | 142 | 123 | 139 | 131 | 148 | 119 | 120 | 2118 |
| 25.0 | 126 | 121 | 144 | 115 | 129 | 142 | 137 | 152 | 124 | 137 | 120 | 131 | 126 | 140 | 124 | 123 | 2096 |
| 26.9 | 124 | 116 | 148 | 120 | 122 | 134 | 142 | 136 | 122 | 137 | 120 | 132 | 123 | 125 | 128 | 117 | 2054 |
| 28.5 | 127 | 118 | 157 | 127 | 123 | 137 | 145 | 129 | 123 | 143 | 122 | 133 | 123 | 124 | 131 | 114 | 2083 |
| 30.0 | 123 | 118 | 164 | 131 | 123 | 138 | 142 | 126 | 120 | 142 | 124 | 132 | 118 | 125 | 129 | 116 | 2076 |
| 32.0 | 118 | 124 | 153 | 134 | 123 | 136 | 138 | 126 | 120 | 137 | 122 | 135 | 119 | 128 | 121 | 120 | 2060 |
| 34.0 | 116 | 124 | 139 | 129 | 123 | 143 | 133 | 123 | 121 | 131 | 123 | 136 | 126 | 129 | 119 | 119 | 2042 |
| 35.9 | 119 | 130 | 138 | 121 | 124 | 194 | 129 | 126 | 120 | 134 | 127 | 130 | 127 | 140 | 121 | 116 | 2105 |
| 37.7 | 120 | 131 | 143 | 120 | 130 | 248 | 125 | 136 | 123 | 146 | 126 | 124 | 122 | 158 | 126 | 118 | 2205 |
| 39.5 | 117 | 123 | 135 | 121 | 125 | 182 | 131 | 142 | 120 | 164 | 122 | 122 | 118 | 155 | 125 | 120 | 2128 |
| 41.2 | 132 | 125 | 143 | 125 | 126 | 171 | 141 | 157 | 126 | 256 | 127 | 132 | 129 | 150 | 128 | 127 | 2302 |
| 43.3 | 139 | 125 | 156 | 128 | 125 | 194 | 133 | 259 | 122 | 165 | 127 | 137 | 128 | 137 | 124 | 131 | 2338 |
| 44.7 | 142 | 123 | 177 | 131 | 123 | 185 | 128 | 165 | 122 | 151 | 126 | 131 | 125 | 132 | 119 | 138 | 2225 |
| 46.2 | 152 | 128 | 179 | 134 | 126 | 174 | 128 | 142 | 128 | 142 | 126 | 130 | 123 | 130 | 117 | 155 | 2218 |
| 47.7 | 204 | 132 | 160 | 134 | 132 | 176 | 135 | 130 | 137 | 145 | 129 | 132 | 125 | 131 | 120 | 160 | 2288 |
| 49.7 | 155 | 133 | 138 | 132 | 136 | 170 | 136 | 129 | 132 | 139 | 134 | 135 | 122 | 133 | 127 | 139 | 2196 |
| 51.6 | 136 | 134 | 126 | 142 | 151 | 155 | 128 | 131 | 129 | 136 | 131 | 139 | 122 | 136 | 129 | 133 | 2166 |
| 53.5 | 130 | 134 | 133 | 156 | 261 | 148 | 134 | 129 | 133 | 138 | 130 | 147 | 139 | 142 | 136 | 153 | 2352 |
| 54.9 | 132 | 139 | 133 | 151 | 155 | 148 | 140 | 129 | 130 | 140 | 129 | 151 | 158 | 144 | 135 | 175 | 2296 |
| 56.2 | 136 | 146 | 137 | 151 | 146 | 147 | 143 | 139 | 129 | 145 | 129 | 153 | 253 | 152 | 142 | 271 | 2527 |
| 57.6 | 128 | 140 | 138 | 153 | 138 | 137 | 133 | 144 | 123 | 138 | 120 | 142 | 169 | 146 | 135 | 164 | 2254 |
| 59.8 | 120 | 123 | 131 | 143 | 123 | 129 | 127 | 127 | 119 | 128 | 115 | 129 | 126 | 130 | 121 | 128 | 2027 |
| 61.8 | 115 | 113 | 118 | 118 | 114 | 120 | 123 | 117 | 115 | 120 | 114 | 121 | 119 | 117 | 114 | 114 | 1881 |
| 63.8 | 103 | 103 | 103 | 105 | 103 | 104 | 104 | 105 | 100 | 103 | 103 | 104 | 105 | 104 | 103 | 105 | 1665 |
| 66.5 | 102 | 102 | 103 | 106 | 102 | 104 | 105 | 104 | 101 | 103 | 104 | 103 | 104 | 103 | 101 | 103 | 1658 |
| 68.4 | 113 | 115 | 120 | 114 | 115 | 129 | 130 | 116 | 118 | 121 | 123 | 115 | 115 | 114 | 109 | 111 | 1886 |
| 70.1 | 123 | 130 | 134 | 125 | 126 | 151 | 141 | 127 | 128 | 129 | 136 | 127 | 112 | 132 | 118 | 118 | 2065 |
| 71.6 | 123 | 139 | 137 | 138 | 136 | 151 | 138 | 129 | 133 | 130 | 135 | 127 | 112 | 148 | 119 | 122 | 2124 |
| 73.1 | 126 | 146 | 145 | 159 | 139 | 147 | 141 | 133 | 141 | 131 | 136 | 129 | 114 | 150 | 120 | 129 | 2195 |
| 74.6 | 138 | 165 | 174 | 177 | 142 | 159 | 152 | 139 | 184 | 139 | 149 | 134 | 127 | 145 | 128 | 135 | 2394 |
| 76.2 | 142 | 203 | 264 | 288 | 139 | 171 | 162 | 139 | 143 | 146 | 168 | 141 | 128 | 140 | 139 | 140 | 2663 |
| 78.0 | 144 | 155 | 166 | 166 | 143 | 155 | 168 | 139 | 135 | 152 | 228 | 149 | 128 | 141 | 161 | 141 | 2478 |
| 79.5 | 141 | 136 | 140 | 151 | 143 | 140 | 182 | 138 | 134 | 153 | 170 | 156 | 127 | 139 | 189 | 139 | 2384 |
| 81.6 | 128 | 130 | 127 | 149 | 132 | 143 | 295 | 126 | 132 | 154 | 148 | 228 | 122 | 131 | 146 | 126 | 2425 |
| 83.8 | 116 | 125 | 125 | 132 | 121 | 143 | 164 | 119 | 126 | 137 | 135 | 138 | 114 | 126 | 122 | 116 | 2066 |
| 86.0 | 109 | 121 | 118 | 119 | 124 | 123 | 136 | 116 | 121 | 141 | 122 | 117 | 108 | 122 | 112 | 114 | 1930 |
| 88.1 | 106 | 109 | 105 | 108 | 113 | 111 | 117 | 109 | 108 | 117 | 108 | 107 | 103 | 112 | 106 | 109 | 1758 |
| 89.9 | 95 | 96 | 96 | 99 | 97 | 97 | 98 | 95 | 96 | 100 | 94 | 99 | 93 | 98 | 94 | 95 | 1550 |
| 91.5 | 94 | 94 | 95 | 95 | 95 | 93 | 95 | 93 | 94 | 96 | 94 | 95 | 93 | 96 | 94 | 94 | 1518 |

well. The exceptional points, as for B-1, closely correlate with the occurrence of significantly larger tube areas adjacent to the taps registering the higher pressures (i.e., tube 15 at 19.5 cm; tubes 2, 3, and 4 at 76.2 cm; see Tables 3.3 and 3.4). Hence, in comparing B-2 flow channel restriction profiles with averaged pressure losses (Figs. 3.34 through 3.37), one concludes that while local deformation features cause local pressure perturbations, the general shape of the pressure profile follows the gross flow channel restriction profiles. And again, as for B-1, no preference for either restriction definition can be made by visual comparisons of Figs. 3.34 to 3.37.

When the B-2 and reference bundle axial pressure loss profiles below 0 cm in Figs. 3.34 to 3.37 are compared, both profiles are seen to closely agree in this zone. For such pressure measurements, made under geometrically identical conditions but with different flow rates and fluid temperatures, the ratio of the burst to reference bundle pressure may be approximated as:

$$\frac{\Delta P_B}{\Delta P_R} = \left(\frac{(Re_R)^{2-n_R}}{(Re_B)^{2-n_B}}\right)\left(\frac{V_B}{V_R}\right)^2 , \tag{3.2}$$

where

$\Delta P \equiv$ pressure loss,
$Re \equiv$ Reynolds number,
$V \equiv$ volumetric flow rate,
$n \equiv$ exponent in $\Delta P \propto Re^n$ proportionality, Eq. (3.1),
$B \equiv$ burst bundle subscript,
$R \equiv$ reference bundle subscript.

An estimate of the precision of reported flow rates and Reynolds numbers may be made by computing the $\Delta P_B/\Delta P_R$ ratio, since the pressure profiles indicate this ratio to be about unity below 0 cm. The four B-2 to reference bundle volumetric flow rate ratios, in order of ascending flow rates, are 1.03, 1.01, 1.00, and 1.00. The ratios of reference to B-2

Reynolds numbers are, respectively, 0.98, 0.96, 1.00, and 1.00. Assuming that $N_B \cong N_R \cong 1.8$, the corresponding $\Delta P_B/\Delta P_R$ ratios are 1.06, 1.01, 1.00, and 1.00, respectively. As significant uncertainties exist in the lower-magnitude flow rates, this trend of $\Delta P_B/\Delta P_R$ ratios approaching unity with ascending flow rates is consistent with previous comments made on this topic in Sect. 2.4. These rough comparisons between the $\Delta P_B/\Delta P_R$ ratios of unity predicted by the pressure profile data against the corresponding calculated ratios (predicted with Reynolds number and flow rate data) point out that such discrepancies exist, are significant, and are on an order of magnitude consistent with data precision limits. (See Sect. 3.2.)

When the general axial averaged pressure profiles of B-2 in Figs. 3.34 through 3.37 are compared against flow area restriction profiles, two features are striking relative to similar B-1 comparisons in Figs. 3.25 through 3.28. First is the smoothness of B-2's axial pressure and restriction profiles (contrasted with B-1's) in the 20- to 55-cm zone. Up to about 60 cm (comparing Figs. 3.26 and 3.35, 3.27, and 3.36), both bundles seem to cause about the same permanent pressure losses to the system. However, the average integrated pressure losses (i.e., the differential losses at 96 cm) for B-2 are significantly larger than the corresponding B-1 measurements. These and other differential pressure measurements above 60 cm indicate that the severe B-2 restriction at about 76 cm caused the corresponding shroud 1 taps to register significantly larger pressures than they did for the B-1 tests. Also, while Tables 3.1 to 3.4 indicate that the B-2 restriction at 76 cm was somewhat larger than its B-1 counterpart, the difference is not enough to suggest that the B-2 profile should be more difficult to predict than the B-1 profile in this zone. Yet, as will be shown in Sect. 5.5, this was the case. The underestimation of pressures in this zone by the B-2 COBRA-IV model, as well as the fact that the same B-2 pressure measurements are larger relative to those for B-1, naturally leads to a questioning of the validity of these particular pressure measurements. This type of behavior can be construed to be characteristic of the pressure taps recording a nonpiezometric component; the shape of the B-2 blockage at 76 cm may well have diverted flow to such a degree as to jeopardize measurements made there and downstream.

Figure 3.38 plots average integrated pressure losses against the corresponding Reynolds numbers for B-2 and the reference bundle, both in shroud 1. As was the case for the similar B-1 comparison (Fig. 3.29), the B-2 pressure data appear to show the expected functional dependence on Reynolds numbers.

## 3.6 Reference Bundle Tests in Shroud 2

Differential axial pressure loss profiles for the reference bundle in shroud 2 are given in Figs. 3.39 through 3.45. Overall, these data appear to be of about the same quality as the corresponding shroud 1 data. The slopes between the grid spacers are relatively linear; some slight nonlinearities exist immediately downstream from the grids and are, of course, expected. Figure 3.45 suggests that this grid disturbance zone may persist for about 20 cm (12 hydraulic diameters) downstream of the grid. Also visible is some slight separation of pressure measurements made on opposing sides of the shroud. This separation is attributed to the drifting of flow rates as the data were taken.

## 3.7 B-2 Tests in Shroud 2

Figures 3.46 through 3.50 are plots of differential pressure loss profiles taken with the B-2/shroud 2 assembly. As may be seen by comparing these figures with their shroud 1 counterparts (Figs. 3.30 through 3.33), the shapes of the plots are similar. Localized profile features due to deformities near the pressure taps are even reproduced with fairly consistent detail (i.e., pressure spikes due to deformities in tube 15 at 19.5 cm and in tubes 2, 3, and 4 at 76.2; see Tables 3.3 and 3.4). This result is not totally unexpected, since the shroud 2 walls are not much further away from B-2 than was the case for shroud 1.

Figures 3.51 through 3.55 present comparisons between B-2 and reference bundle axial pressure loss profiles (averaged) against B-2 flow channel restriction profiles. As shown, the agreement between the B-2 and reference bundle profiles below 0 cm is very good, implying a $\Delta P_B/\Delta P_R$ ratio of unity [using Eq. (3.2) notation]. The five B-2 to reference bundle volumetric flow rate ratios corresponding to Figs. 3.51 to 3.55 are 1.00, 0.98, 1.01, 1.01, and 1.01. The respective reference bundle to B-2 Reynolds number ratios are 1.02, 1.02, 1.00, 0.96, and 1.00. Computing the $\Delta P_B/\Delta P_R$ ratios for $N_B \cong N_R \cong 1.8$ [see Eq. (3.2)] corresponding to Figs. 3.51 to 3.55 with these values, one obtains $\Delta P_B/\Delta P_R$ ratios of 1.00, 0.96, 1.02, 1.01, and 1.02. While these calculated $\Delta P_B/\Delta P_R$ ratios do not approach unity with increasing flow rates as closely as did similar ratios for previous data sets, these results are still explainable in terms of the precision limits given in Sect. 2.4. Hence, when the $\Delta P_B/\Delta P_R$ ratios of unity implied by the overlain B-2 and reference bundle pressure loss profiles are compared with corresponding $\Delta P_B/\Delta P_R$ ratios based on flow rate and Reynolds number determinations, discrepancies are observable which are indicative of the precision to which volumetric flow rates were measured.

Figure 3.56 compares the average integrated pressure losses of the B-2 and reference bundles in shroud 2 against the corresponding Reynolds numbers; the curve fits to these data are reasonably good.

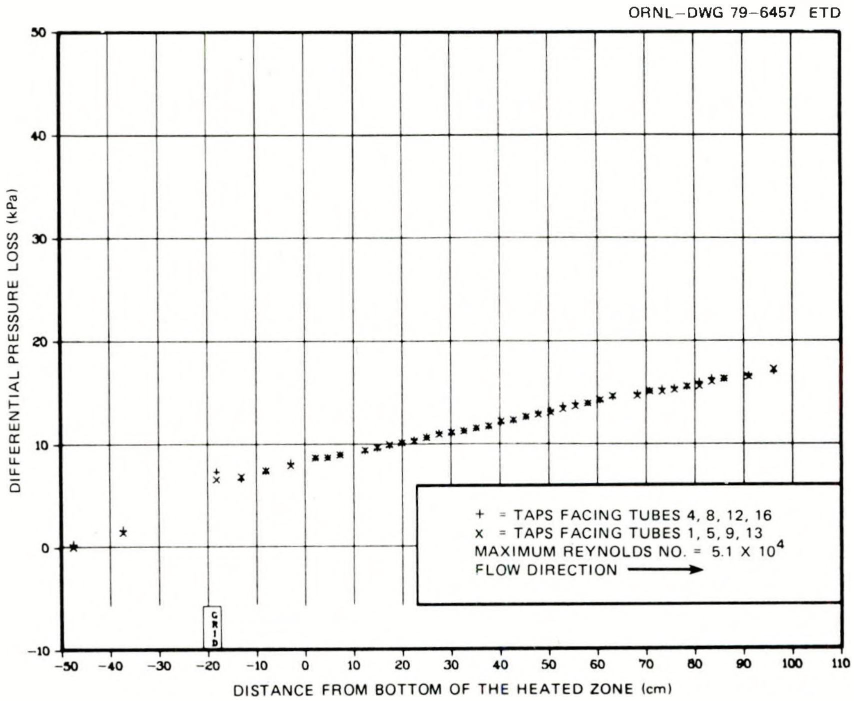



Fig. 3.1. First single-grid test axial pressure loss profiles; flow rate = 9.2 liters/sec.

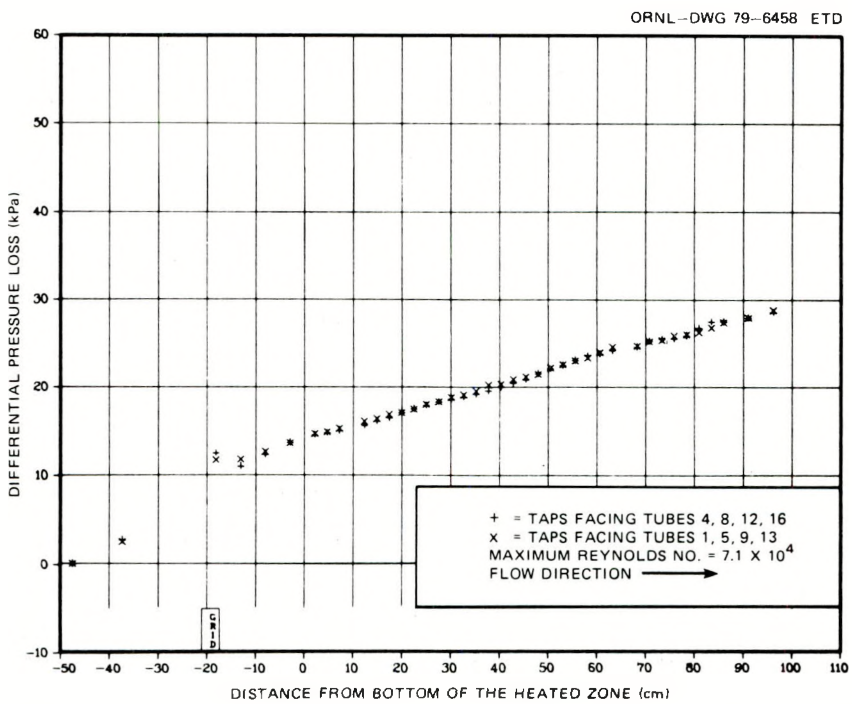



Fig. 3.2. First single-grid test axial pressure loss profiles; flow rate = 12.3 liters/sec.

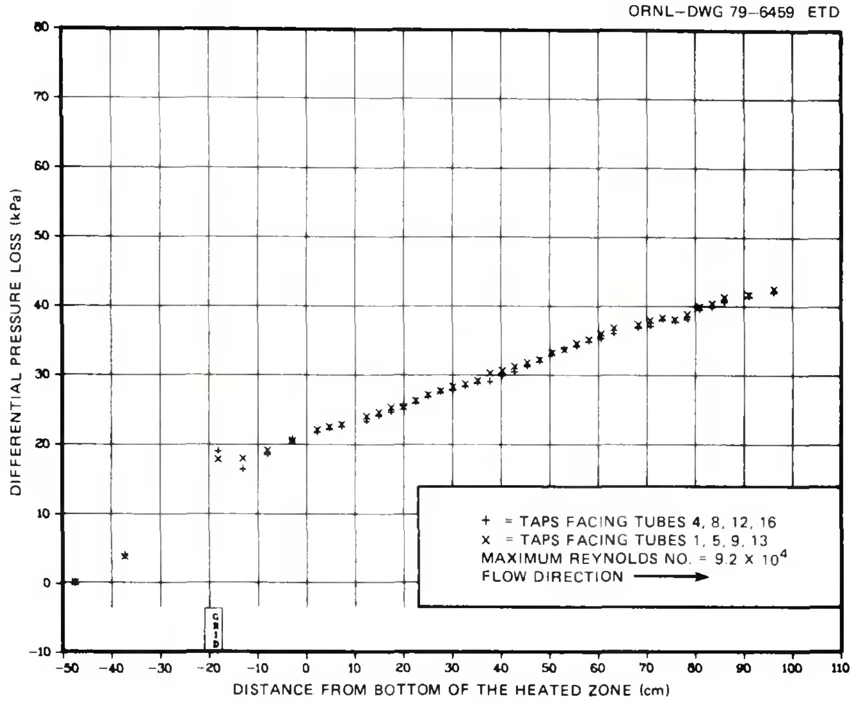



Fig. 3.3. First single-grid test axial pressure loss profiles; flow rate = 15.5 liters/sec.

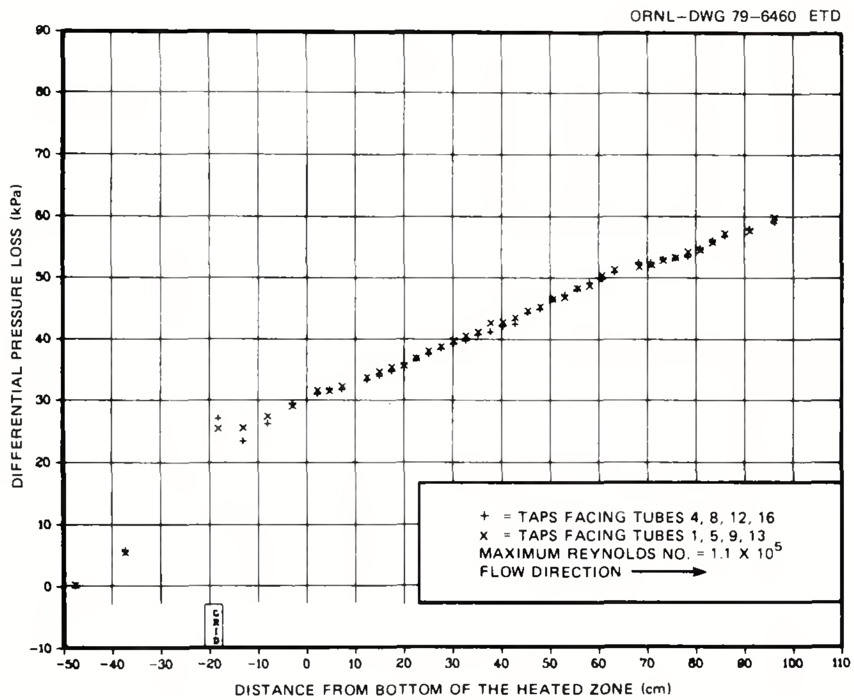



Fig. 3.4. First single-grid test axial pressure loss profiles; flow rate = 18.6 liters/sec.

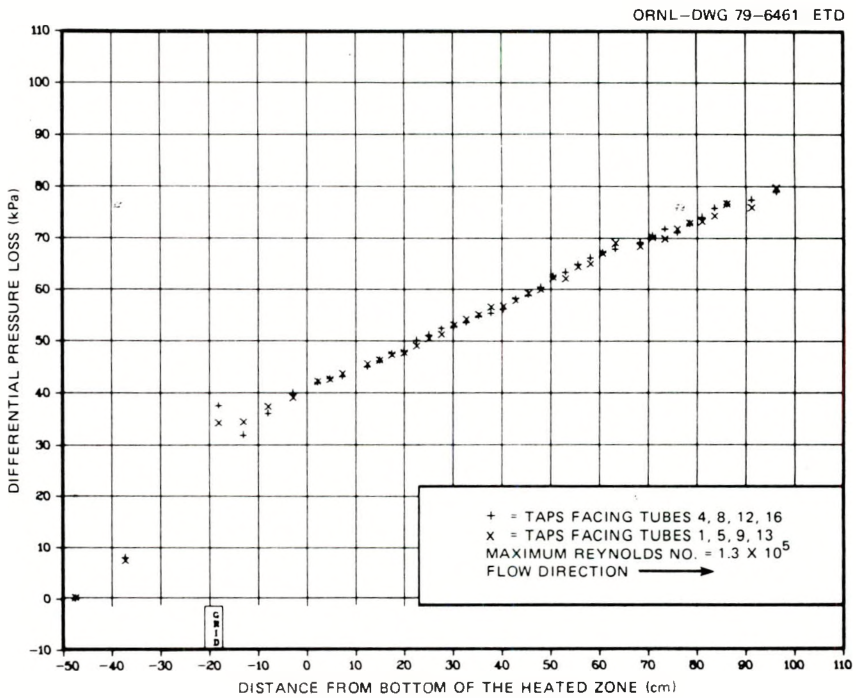



Fig. 3.5. First single-grid test axial pressure loss profiles; flow rate = 21.9 liters/sec.

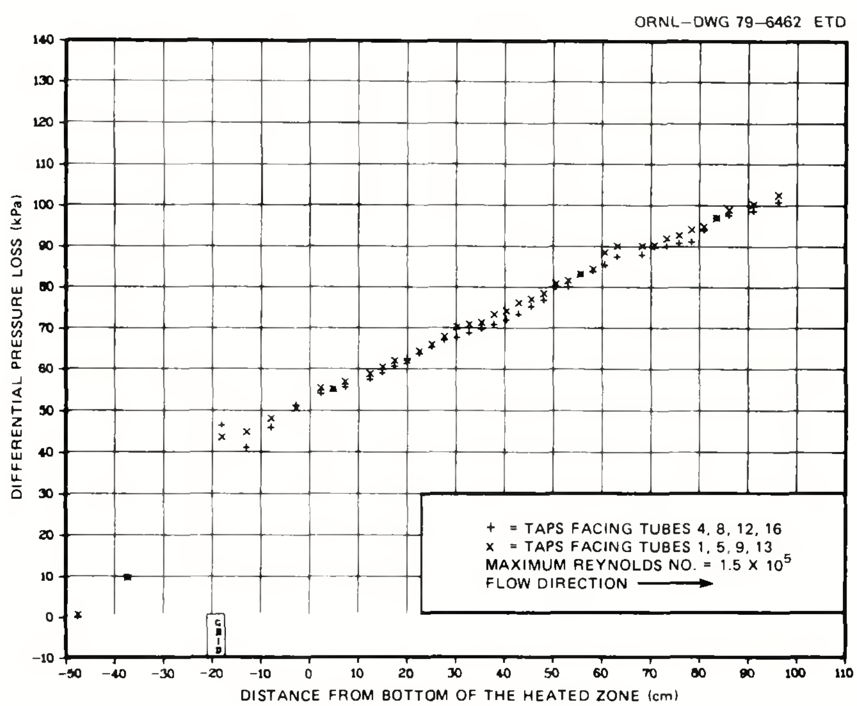



Fig. 3.6. First single-grid test axial pressure loss profiles; flow rate = 25.0 liters/sec.

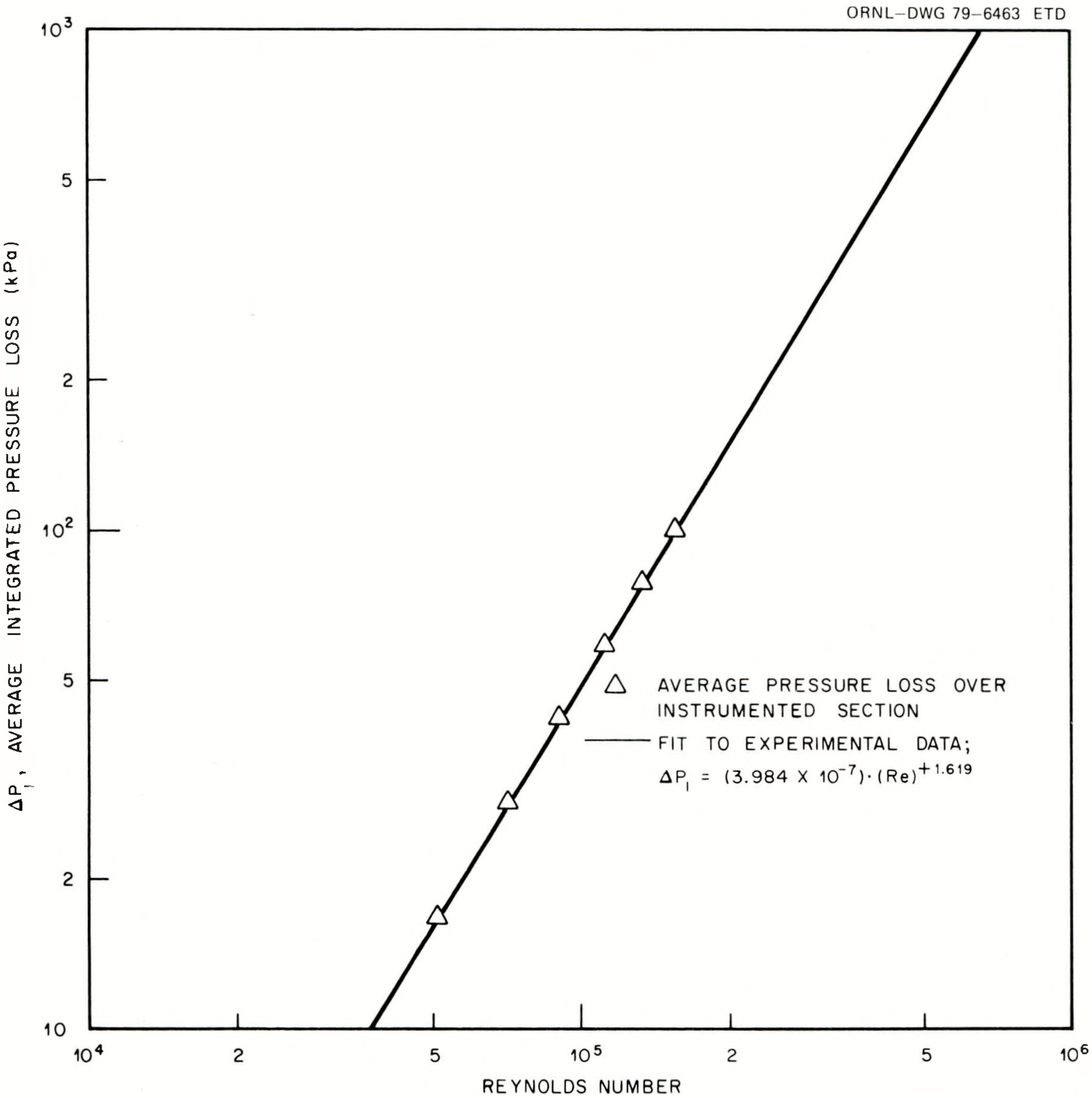



Fig. 3.7. Average integrated pressure losses vs Reynolds number for the first single-grid tests. (Note: The Reynolds numbers used to generate this plot were not limited to two significant figures in contrast with the previously reported values.)

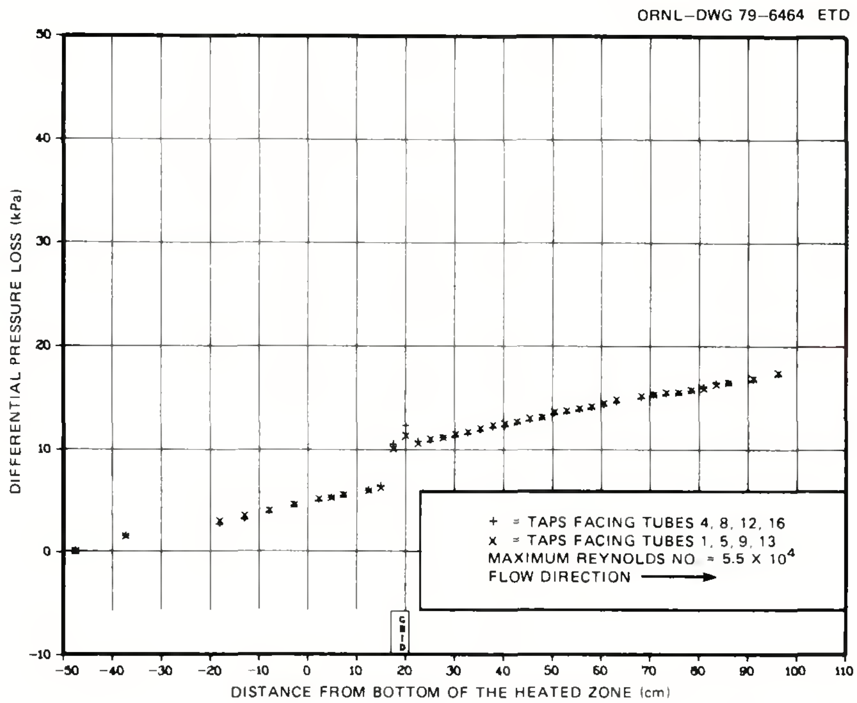



Fig. 3.8. Second single-grid test axial pressure loss profiles; flow rate = 9.36 liters/sec.

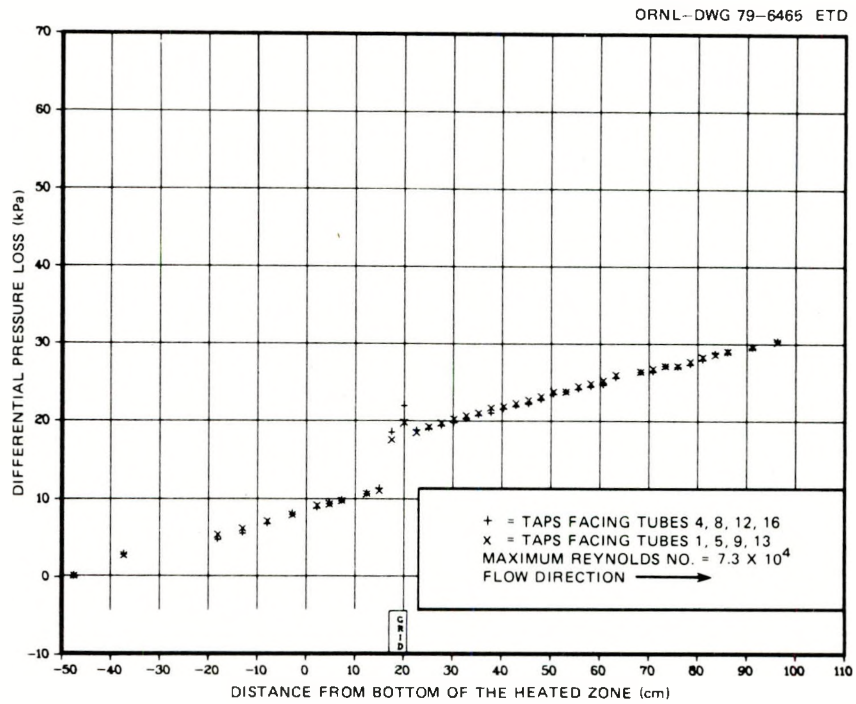



Fig. 3.9. Second single-grid test axial pressure loss profiles; flow rate = 12.7 liters/sec.

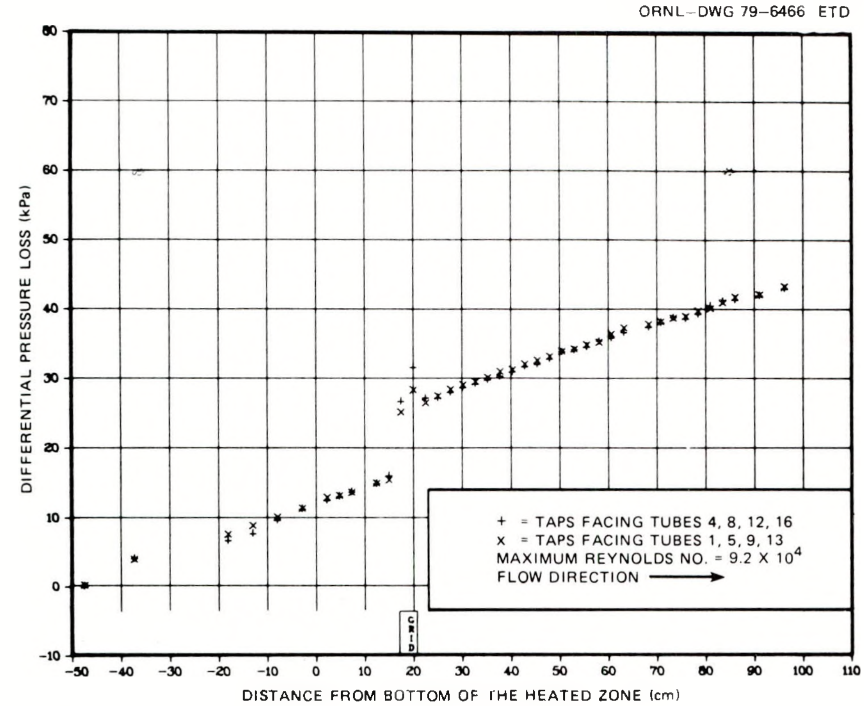



Fig. 3.10. Second single-grid test axial pressure loss profiles; flow rate = 15.6 liters/sec.

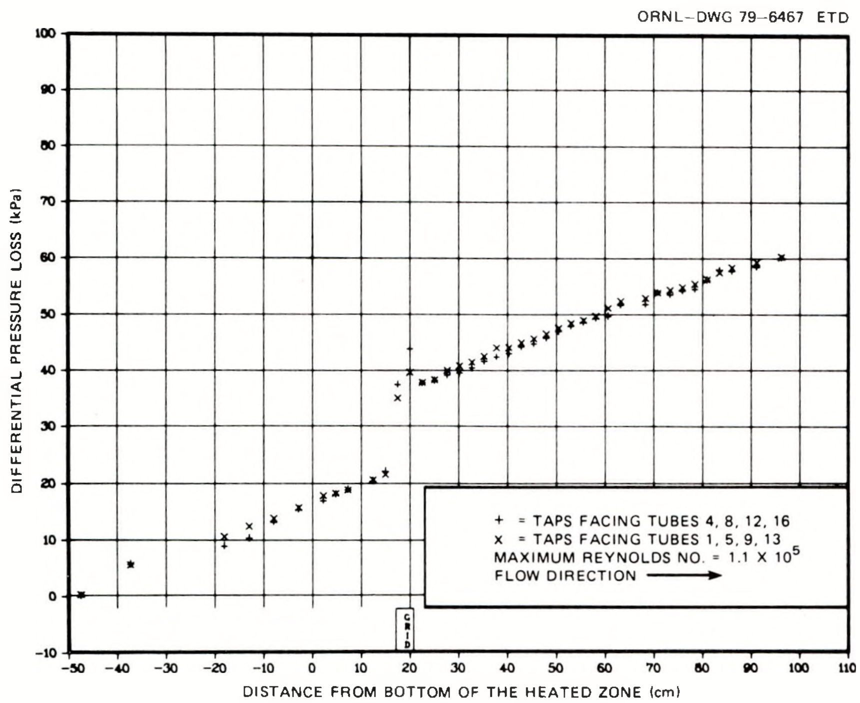



Fig. 3.11. Second single-grid test axial pressure loss profiles; flow rate = 18.8 liters/sec.

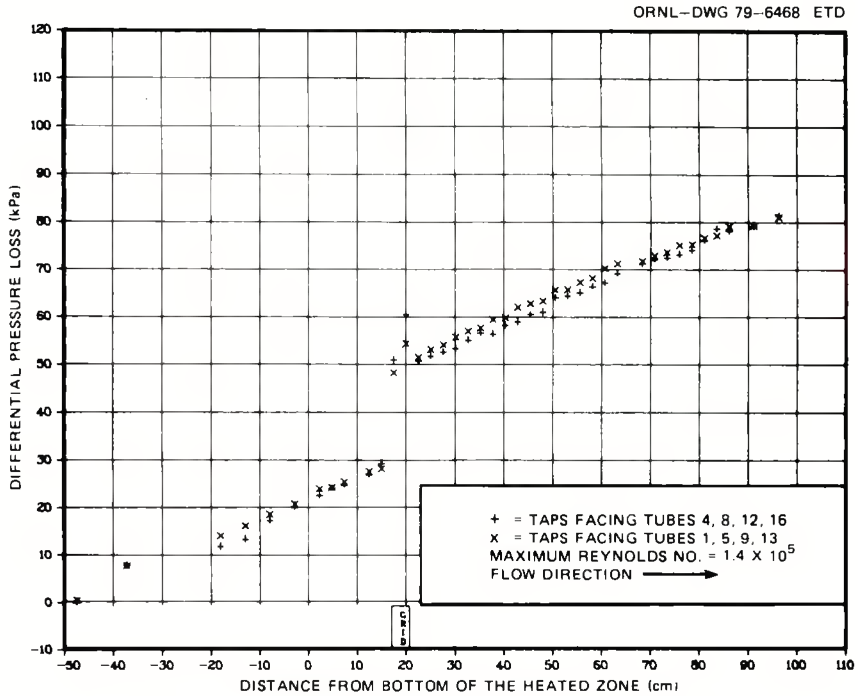



Fig. 3.12. Second single-grid test axial pressure loss profiles; flow rate = 22.1 liters/sec.

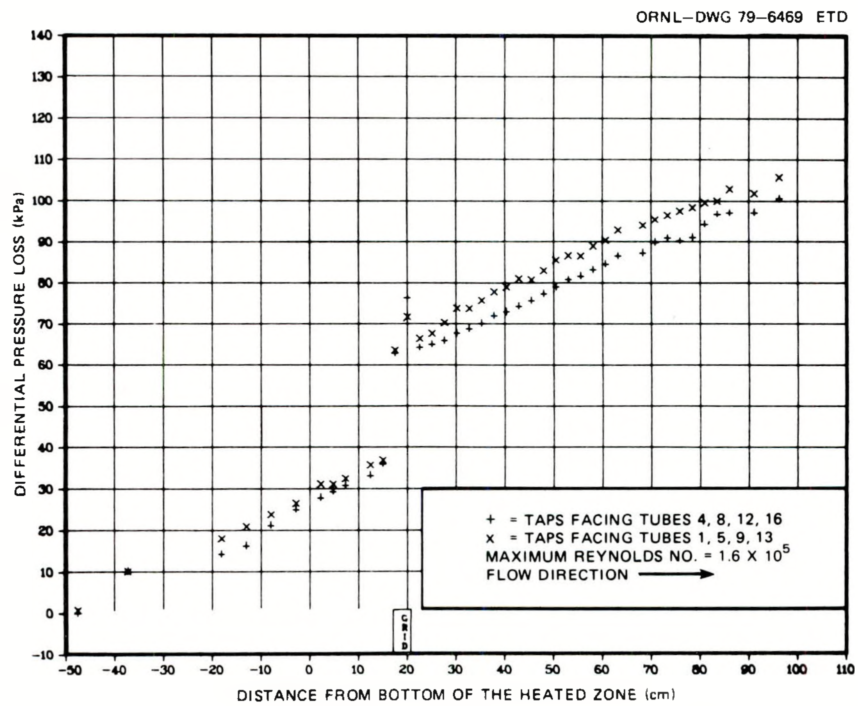



Fig. 3.13. Second single-grid test axial pressure loss profiles; flow rate = 25.3 liters/sec.

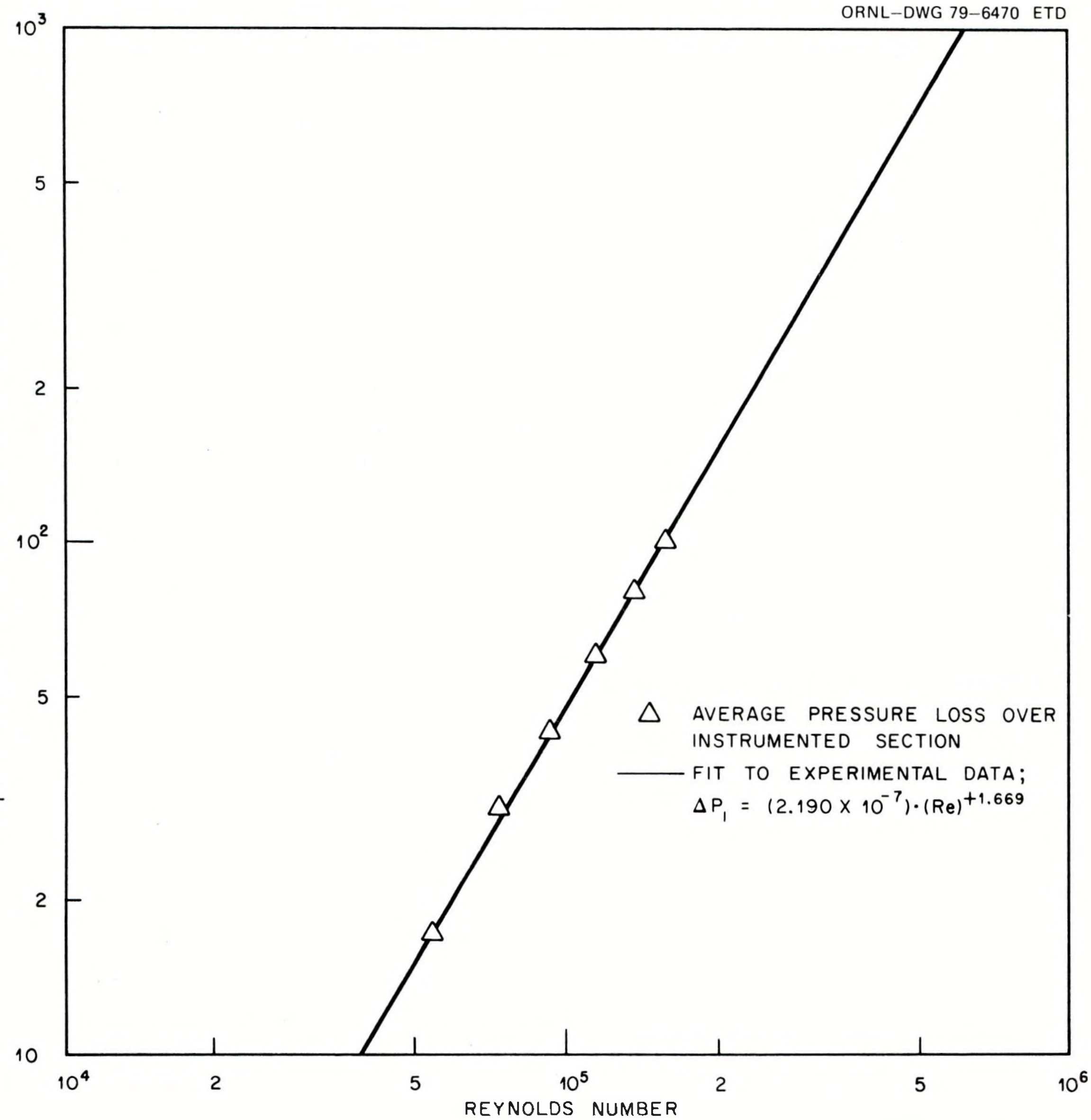



Fig. 3.14. Average integrated pressure losses vs Reynolds number for the second single-grid tests. (Note: The Reynolds numbers used to generate this plot were not limited to two significant figures in contrast with the previously reported values.)

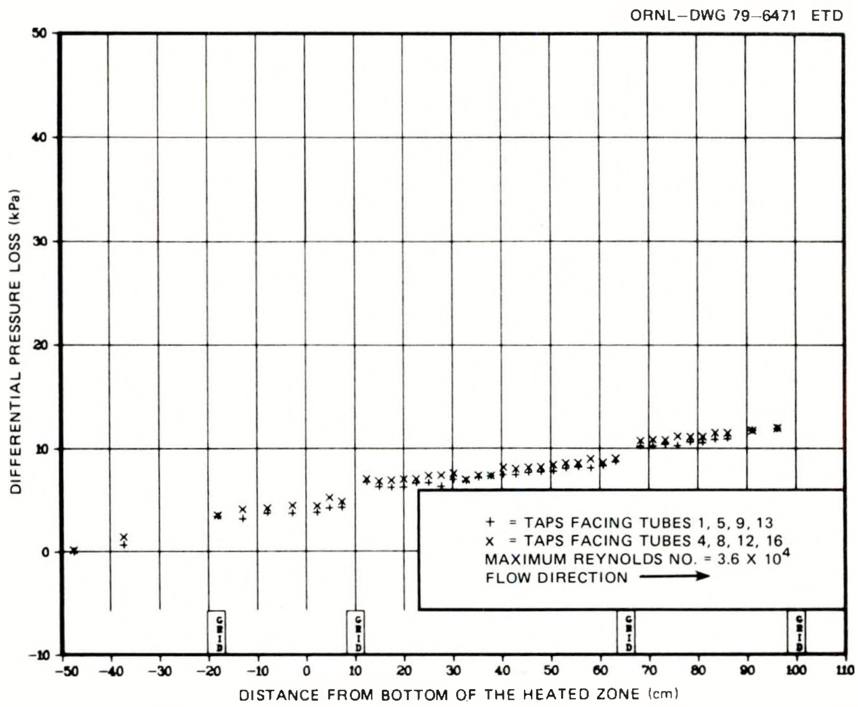



Fig. 3.15. Reference bundle/shroud 1 axial pressure loss profiles; flow rate = 6.77 liters/sec.

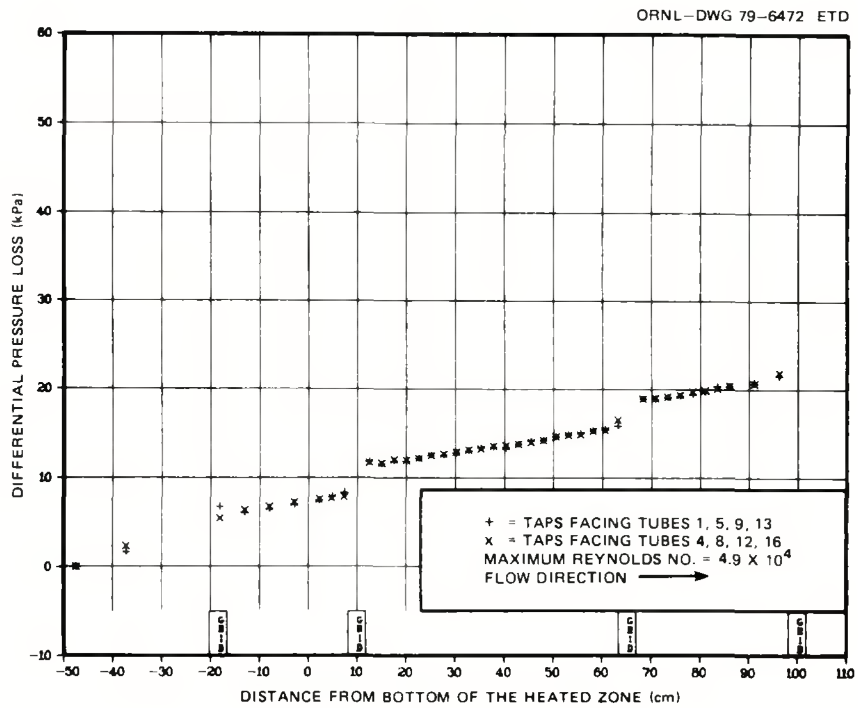



Fig. 3.16. Reference bundle/shroud 1 axial pressure loss profiles; flow rate = 9.22 liters/sec.

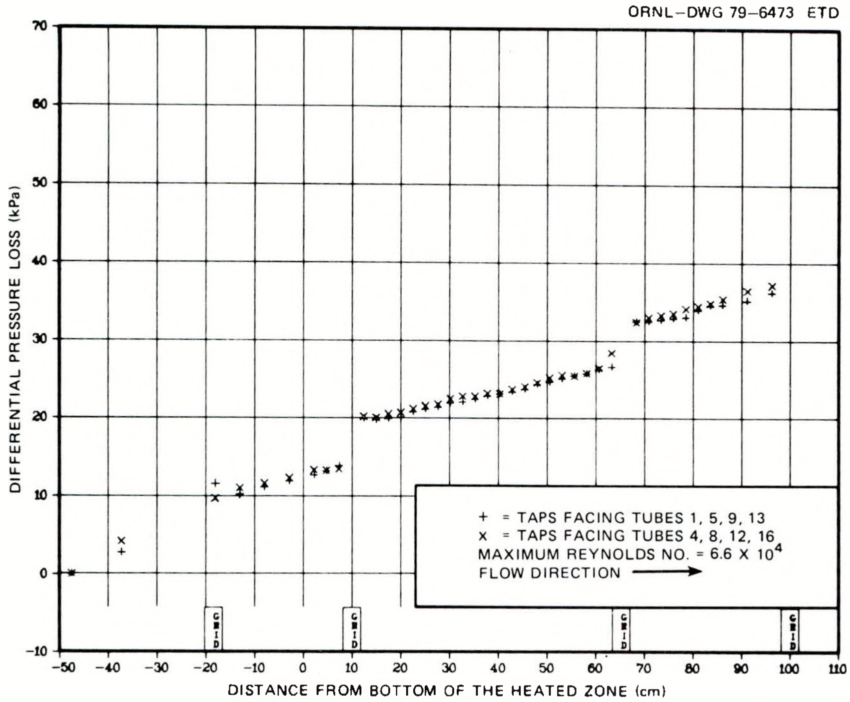



Fig. 3.17. Reference bundle/shroud 1 axial pressure loss profiles; flow rate = 12.5 liters/sec.

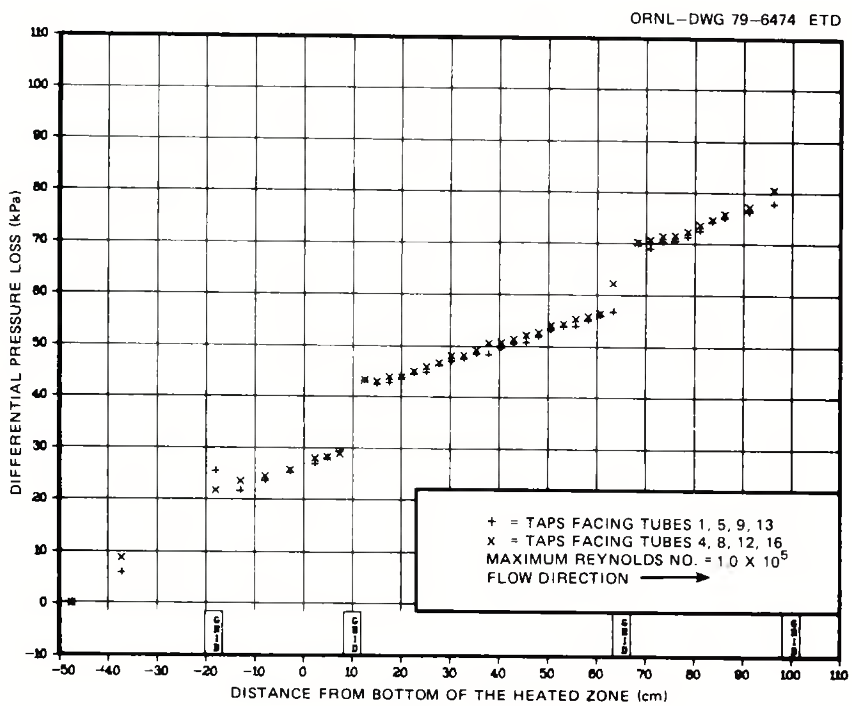



Fig. 3.18. Reference bundle/shroud 1 axial pressure loss profiles; flow rate = 18.9 liters/sec.

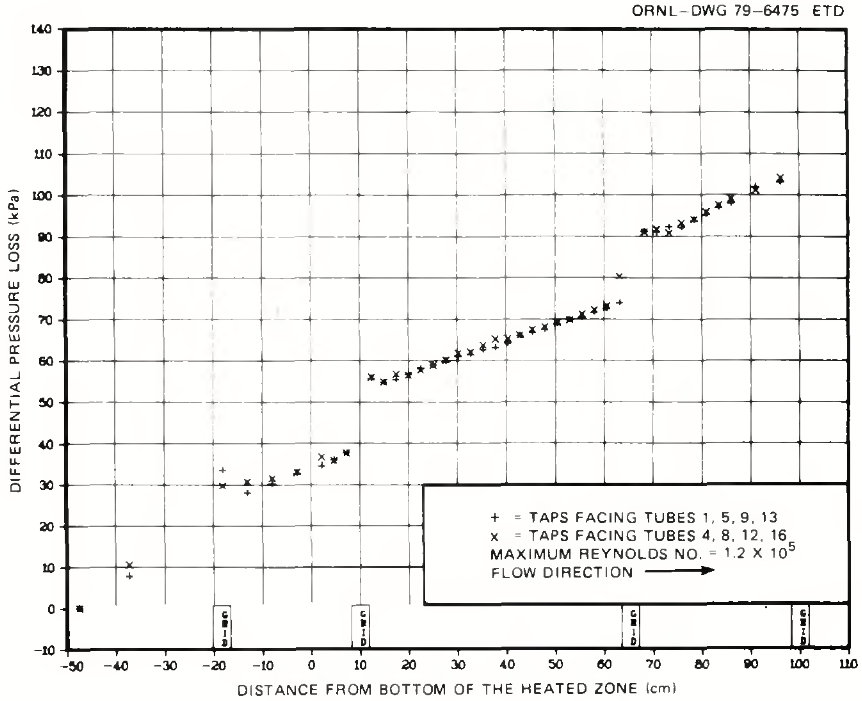



Fig. 3.19. Reference bundle/shroud 1 axial pressure loss profiles; flow rate = 22.1 liters/sec.

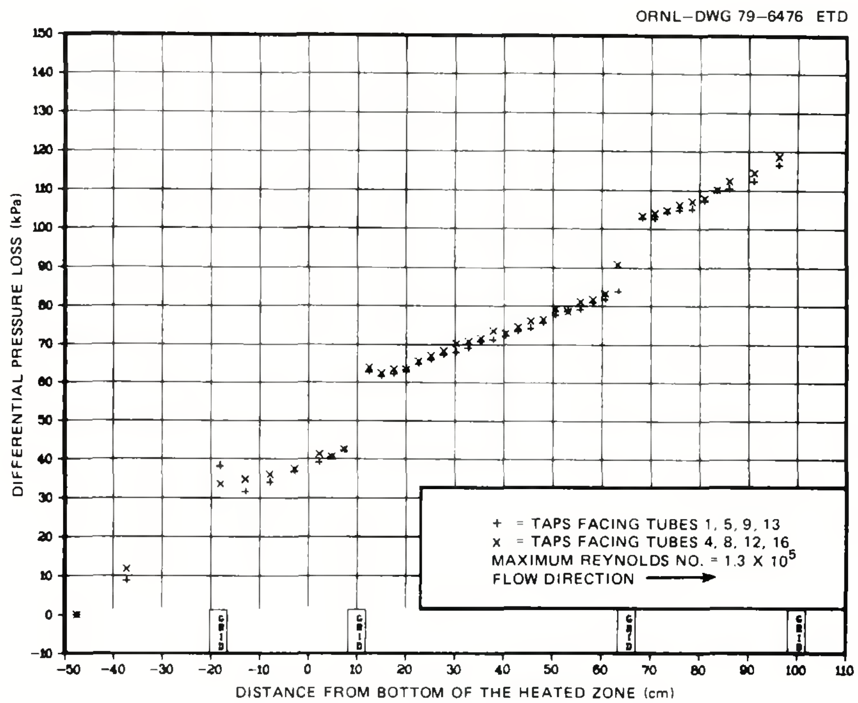



Fig. 3.20. Reference bundle/shroud 1 axial pressure loss profiles; flow rate = 23.9 liters/sec.

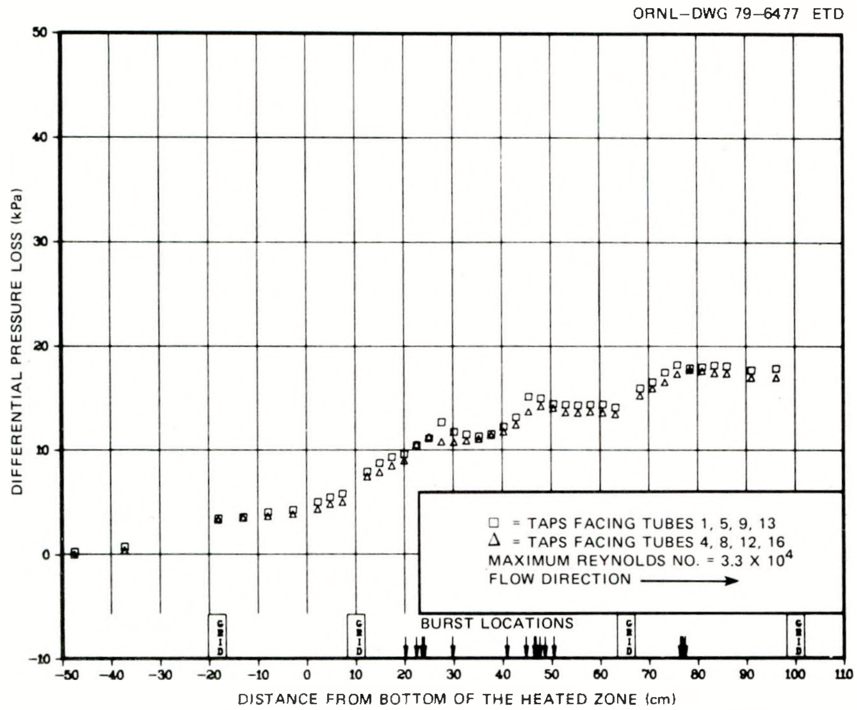



Fig. 3.21. B-1/shroud 1 axial pressure loss profiles; flow rate = 6.31 liters/sec.

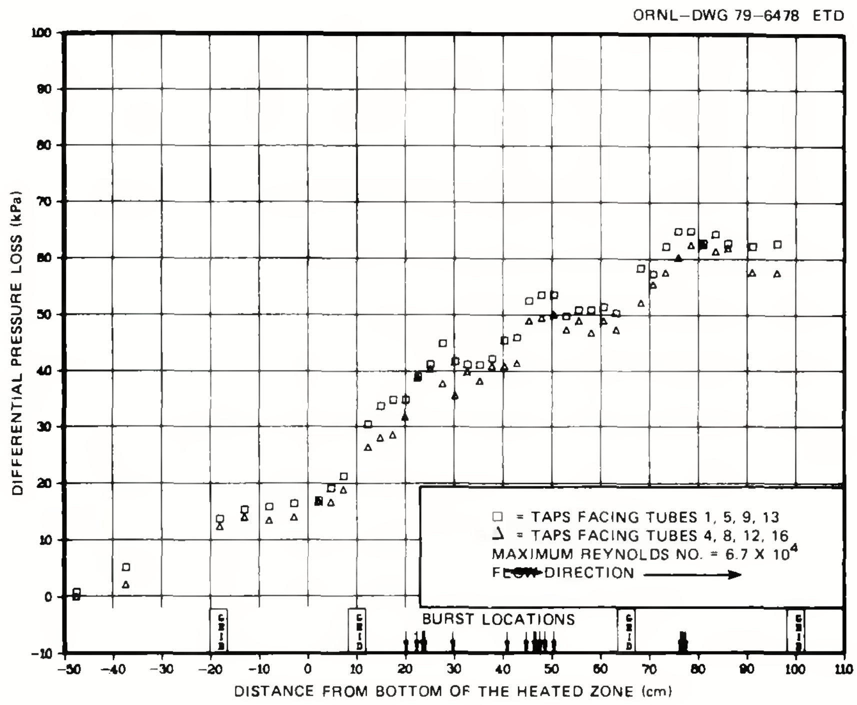



Fig. 3.22. B-1/shroud 1 axial pressure loss profiles; flow rate = 12.8 liters/sec.

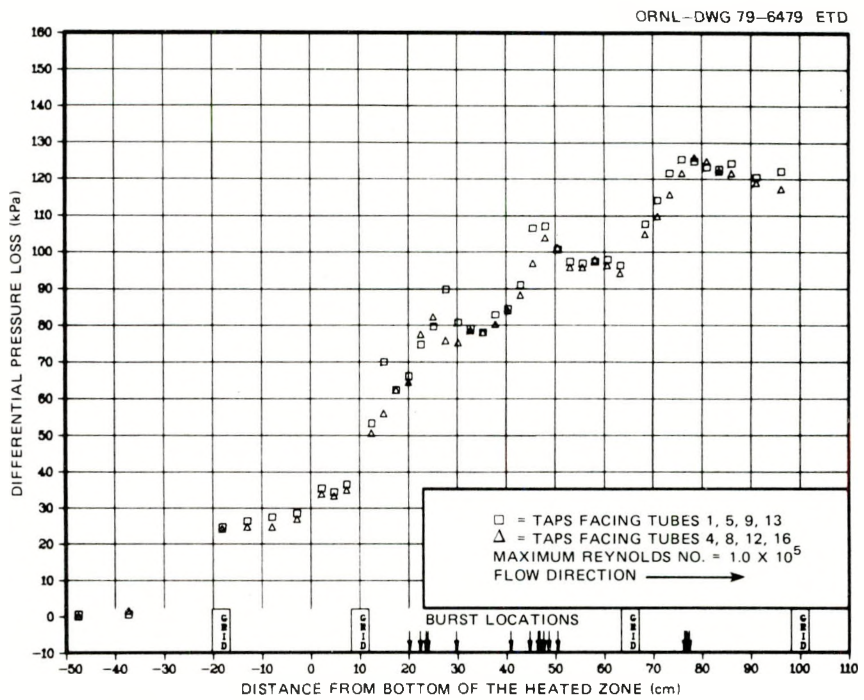



Fig. 3.23. B-1/shroud 1 axial pressure loss profiles; flow rate = 19.1 liters/sec.

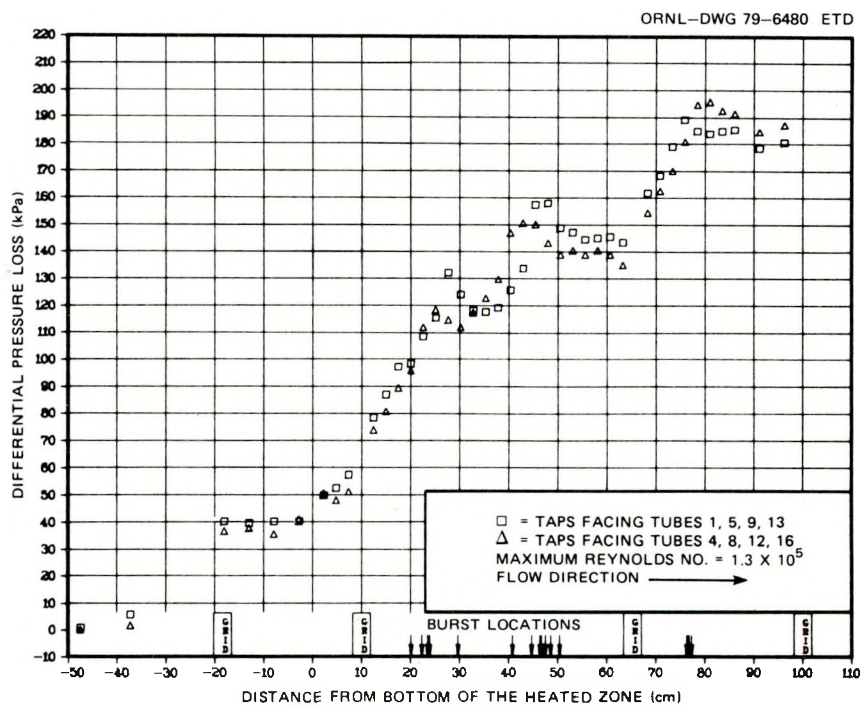



Fig. 3.24. B-1/shroud 1 axial pressure loss profiles; flow rate = 23.9 liters/sec.

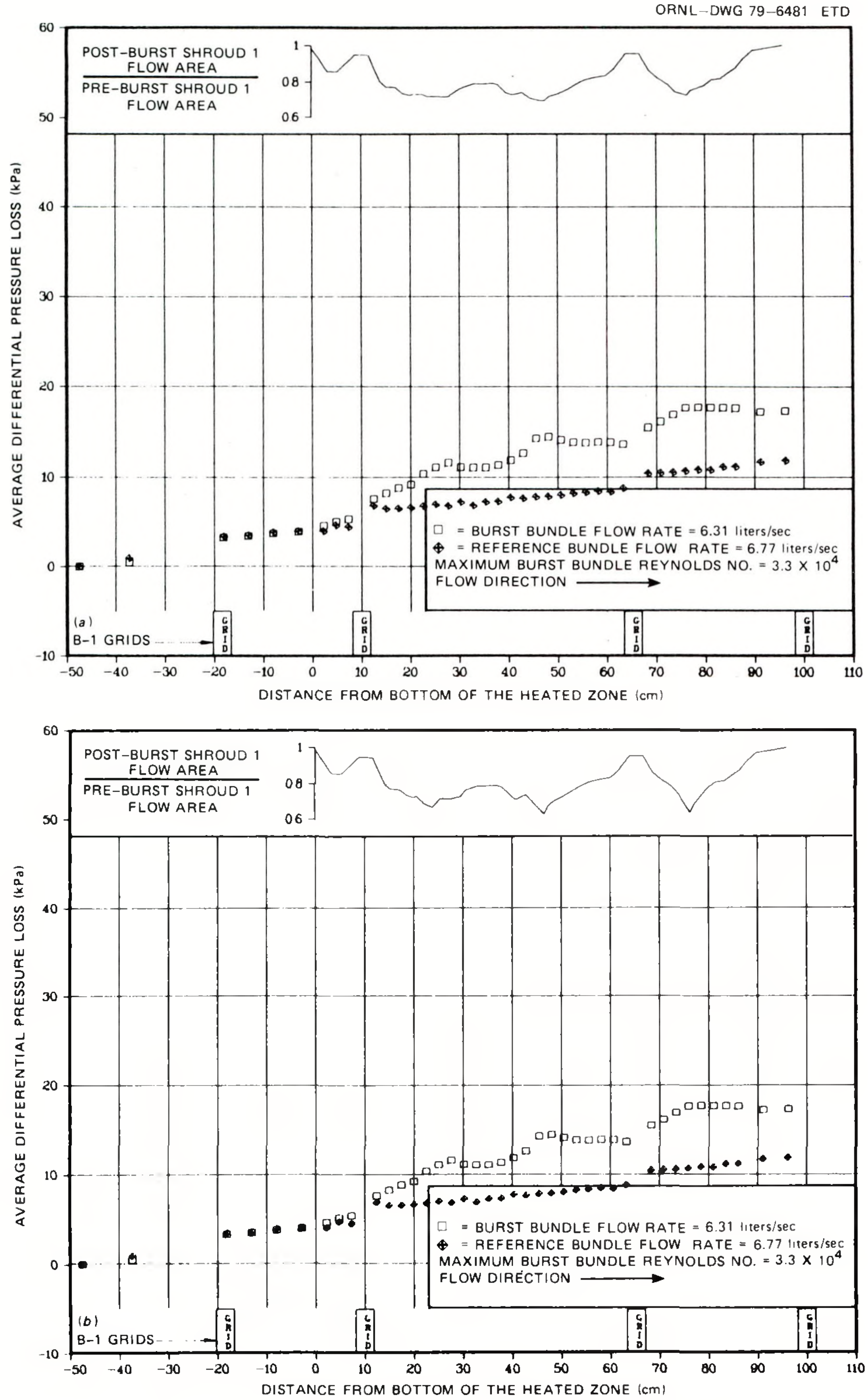



Fig. 3.25. B-1/shroud 1 and reference bundle/shroud 1 axial pressure loss profiles; burst bundle flow rate = 6.31 liters/sec vs: (a) the minimum B-1 restriction profile (b) the maximum B-1 restriction profile.

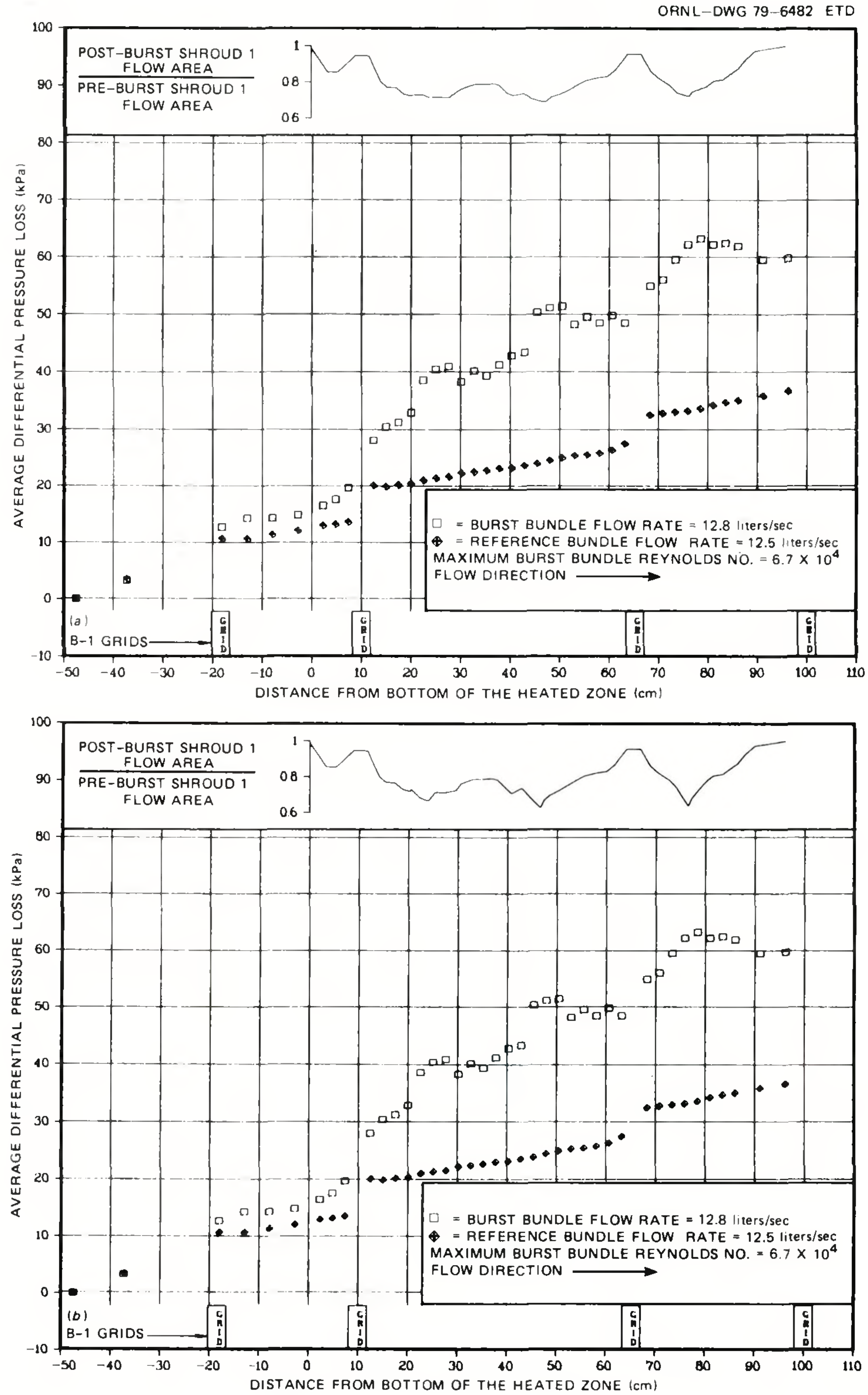



Fig. 3.26. B-1/shroud 1 and reference bundle/shroud 1 axial pressure loss profiles; burst bundle flow rate = 12.8 liters/sec vs: (a) the minimum B-1 restriction profile (b) the maximum B-1 restriction profile.

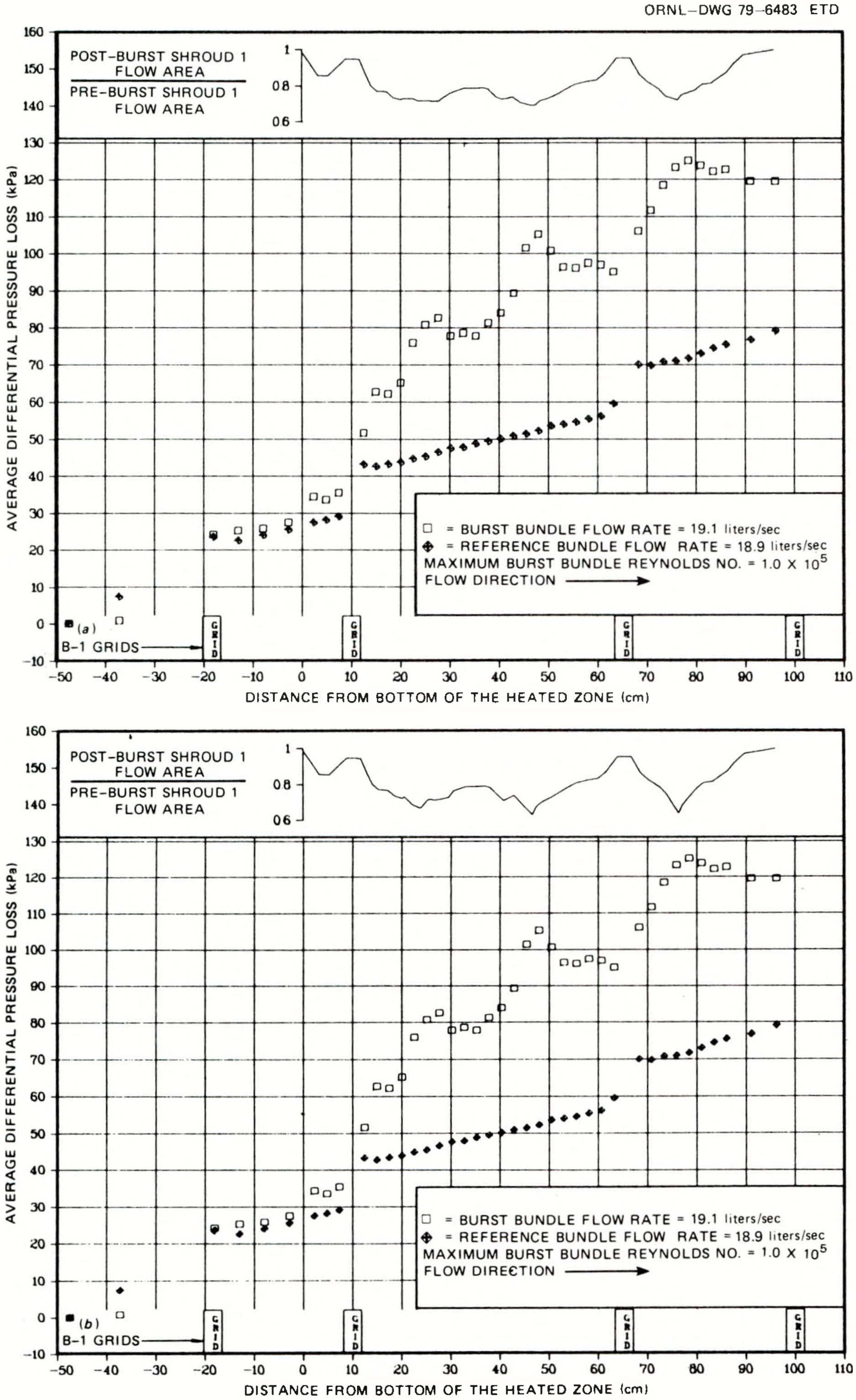



Fig. 3.27. B-1/shroud 1 and reference bundle/shroud 1 axial pressure loss profiles; burst bundle flow rate = 19.1 liters/sec vs: (a) the minimum B-1 restriction profile (b) the maximum B-1 restriction profile.

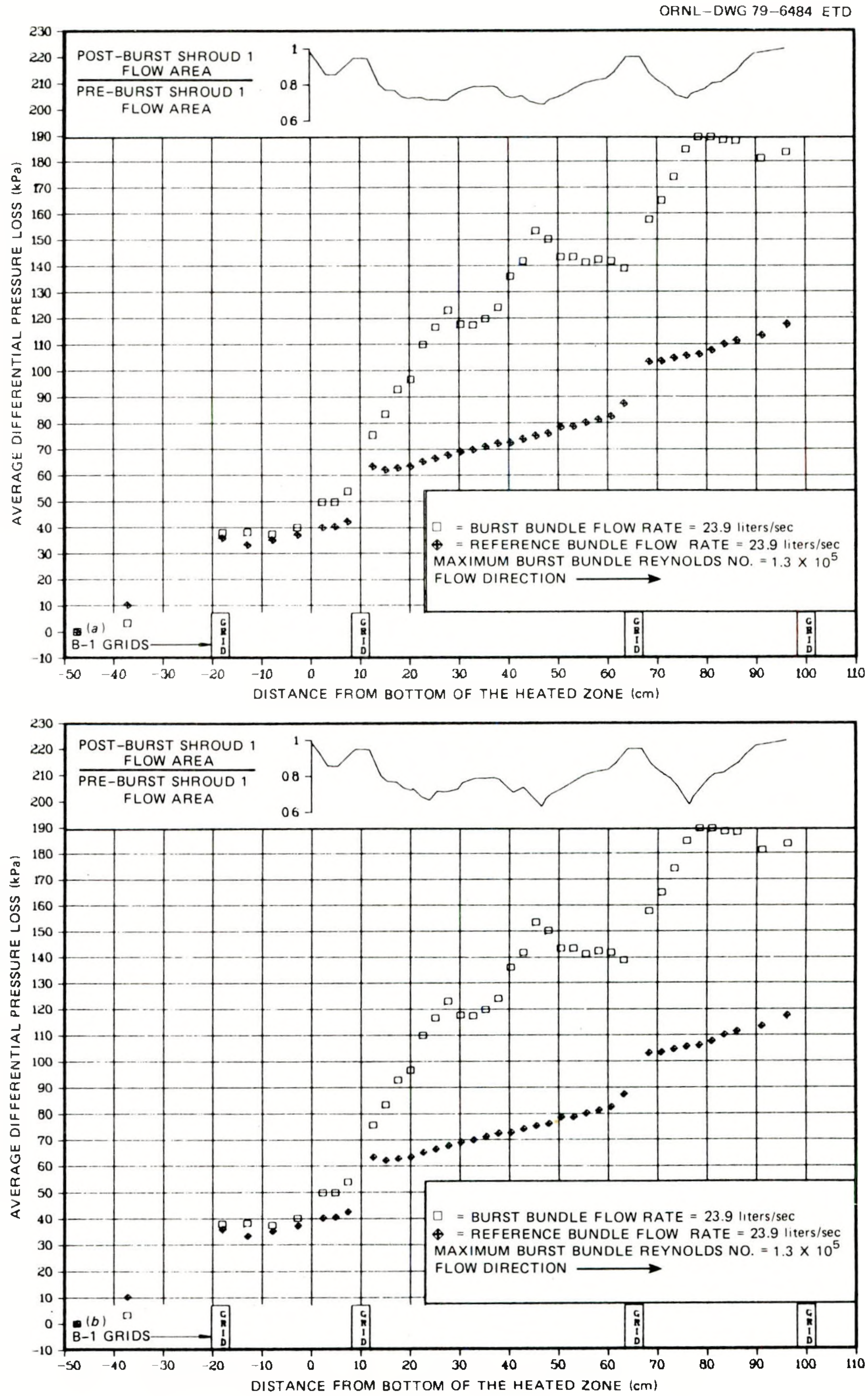



Fig. 3.28. B-1/shroud 1 and reference bundle/shroud 1 axial pressure loss profiles; burst bundle flow rate = 23.9 liters/sec vs: (a) the minimum B-1 restriction profile (b) the maximum B-1 restriction profile.

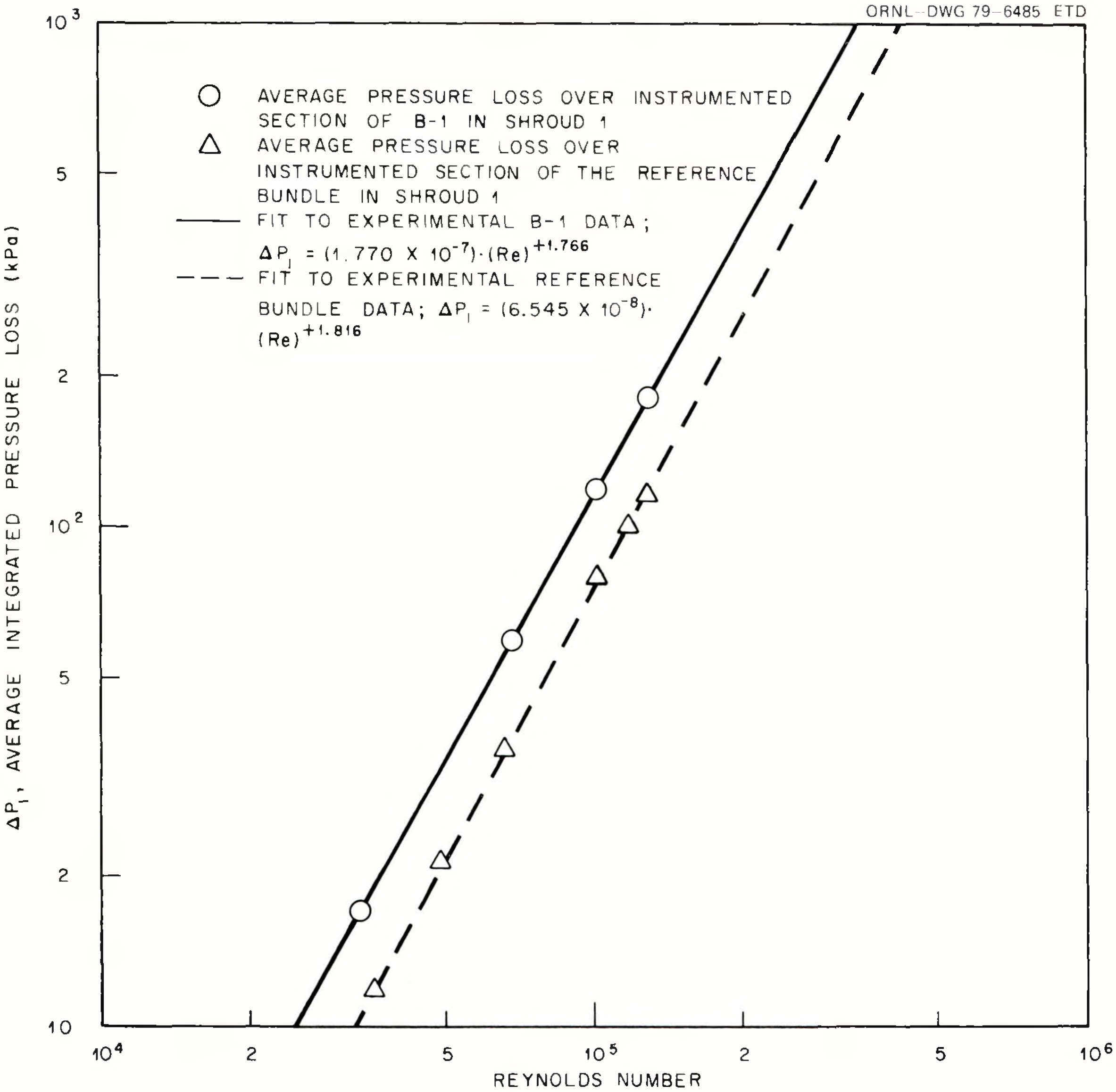



Fig. 3.29. Average integrated pressure losses vs Reynolds number for the B-1 and reference bundle tests in shroud 1. (Note: The Reynolds numbers used to generate this plot were not limited to two significant figures in contrast with the previously reported values.)

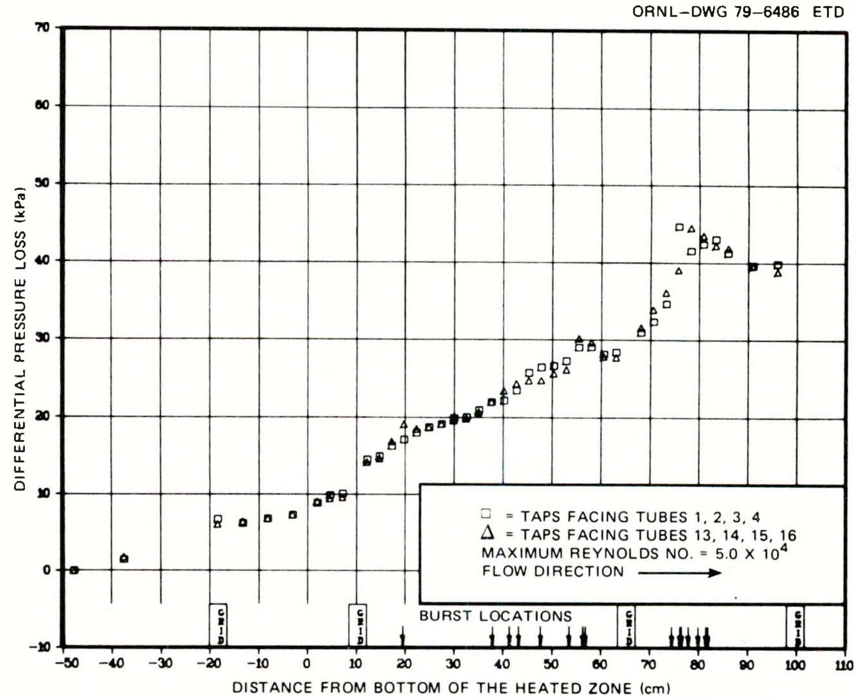



Fig. 3.30. B-2/shroud 1 axial pressure loss profiles; flow rate = 9.46 liters/sec.

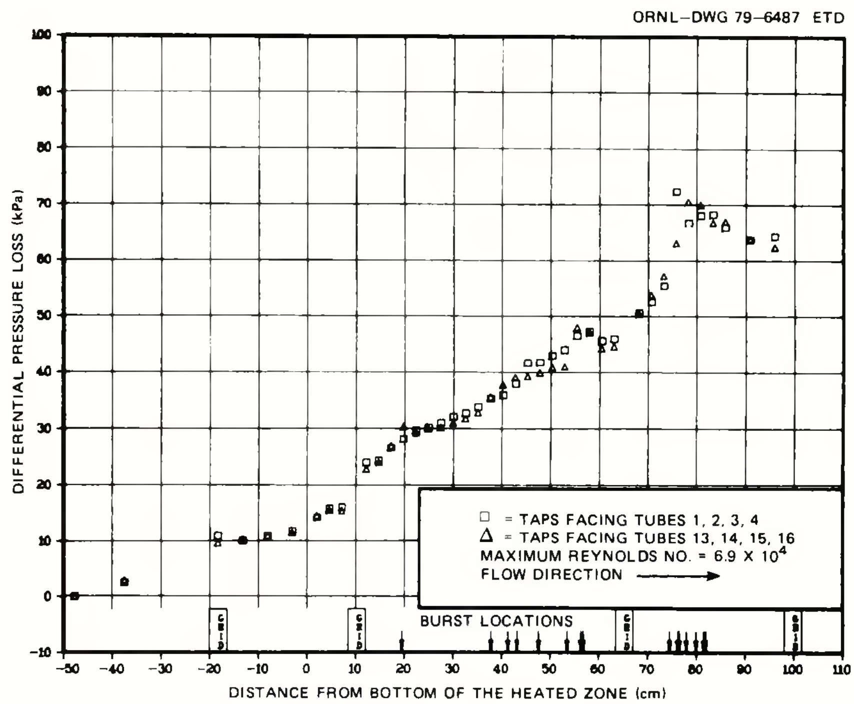



Fig. 3.31. B-2/shroud 1 axial pressure loss profiles; flow rate = 12.6 liters/sec.

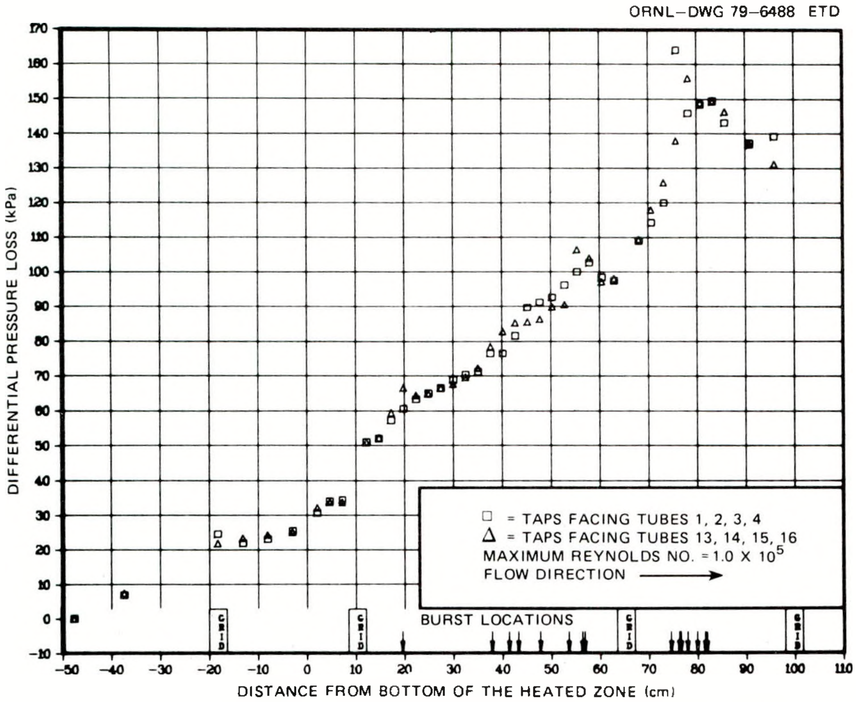



Fig. 3.32. B-2/shroud 1 axial pressure loss profiles; flow rate = 18.9 liters/sec.

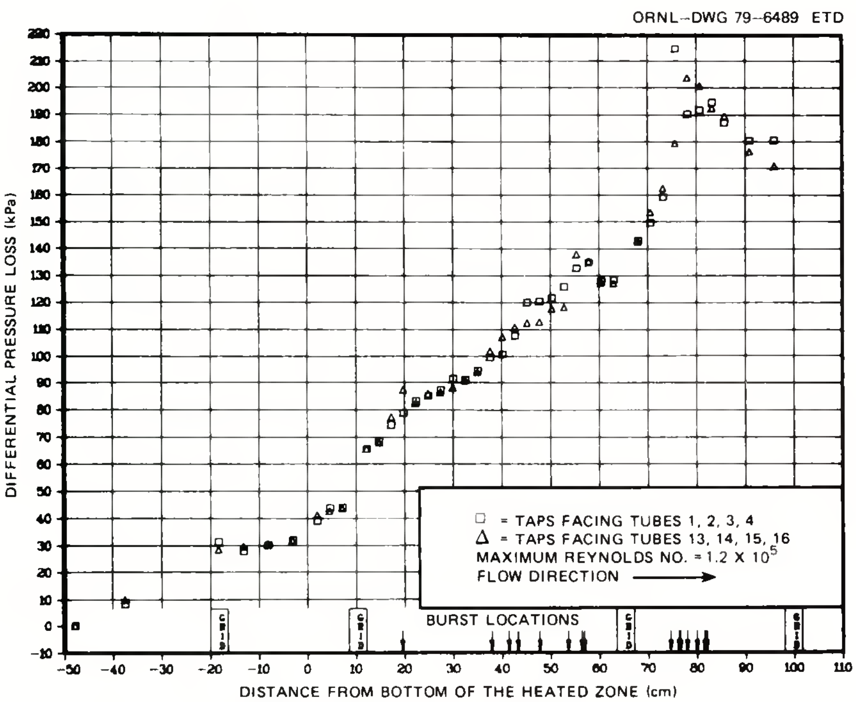



Fig. 3.33. B-2/shroud 1 axial pressure loss profiles; flow rate = 22.0 liters/sec.

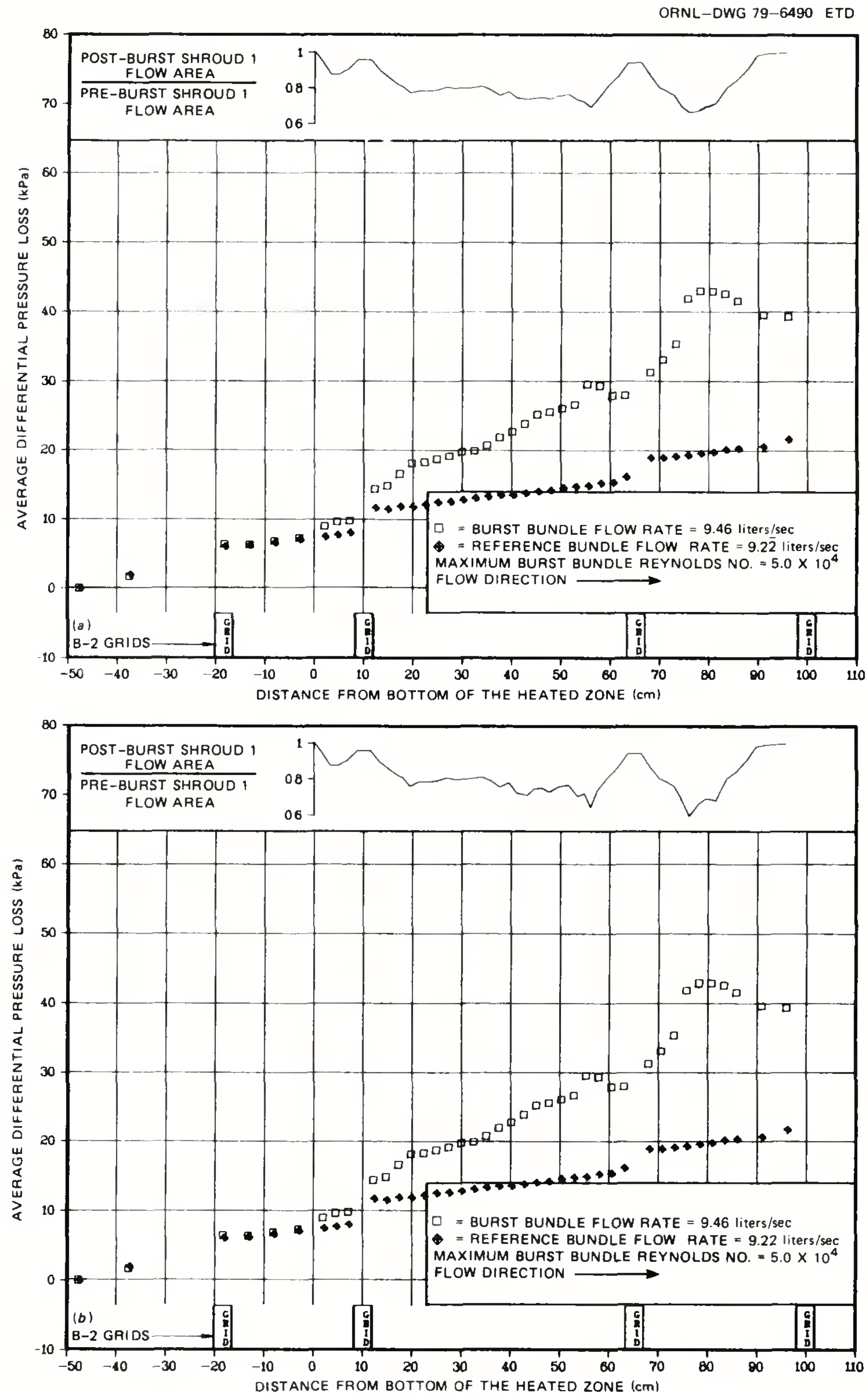



Fig. 3.34. B-2/shroud 1 and reference bundle/shroud 1 axial pressure loss profiles; burst bundle flow rate = 9.46 liters/sec vs: (a) the minimum B-2 restriction profile (b) the maximum B-2 restriction profile.

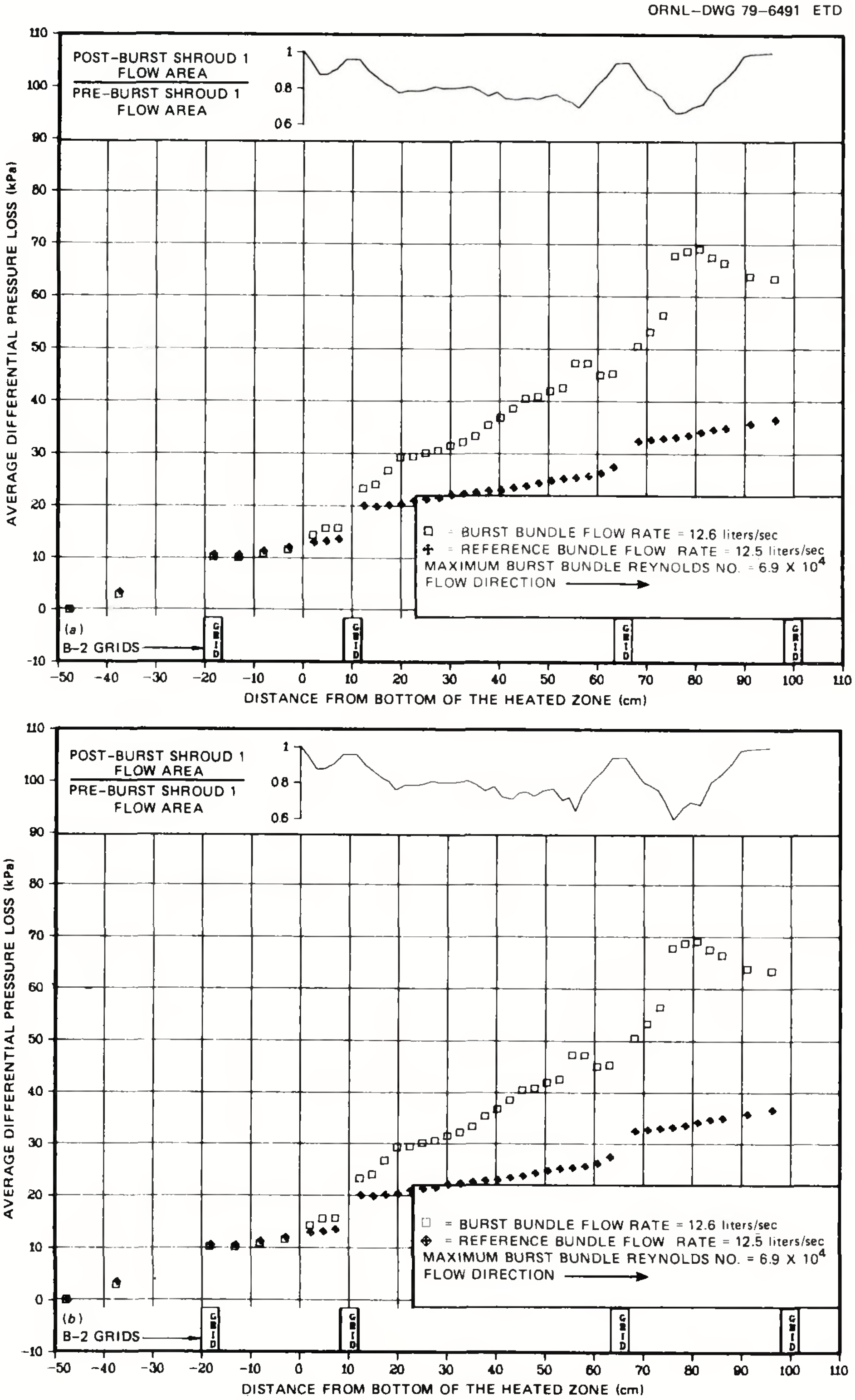



Fig. 3.35. B-2/shroud 1 and reference bundle/shroud 1 axial pressure loss profiles; burst bundle flow rate = 12.6 liters/sec vs: (a) the minimum B-2 restriction profile (b) the maximum B-2 restriction profile.

ORNL–DWG 79–6492 ETD

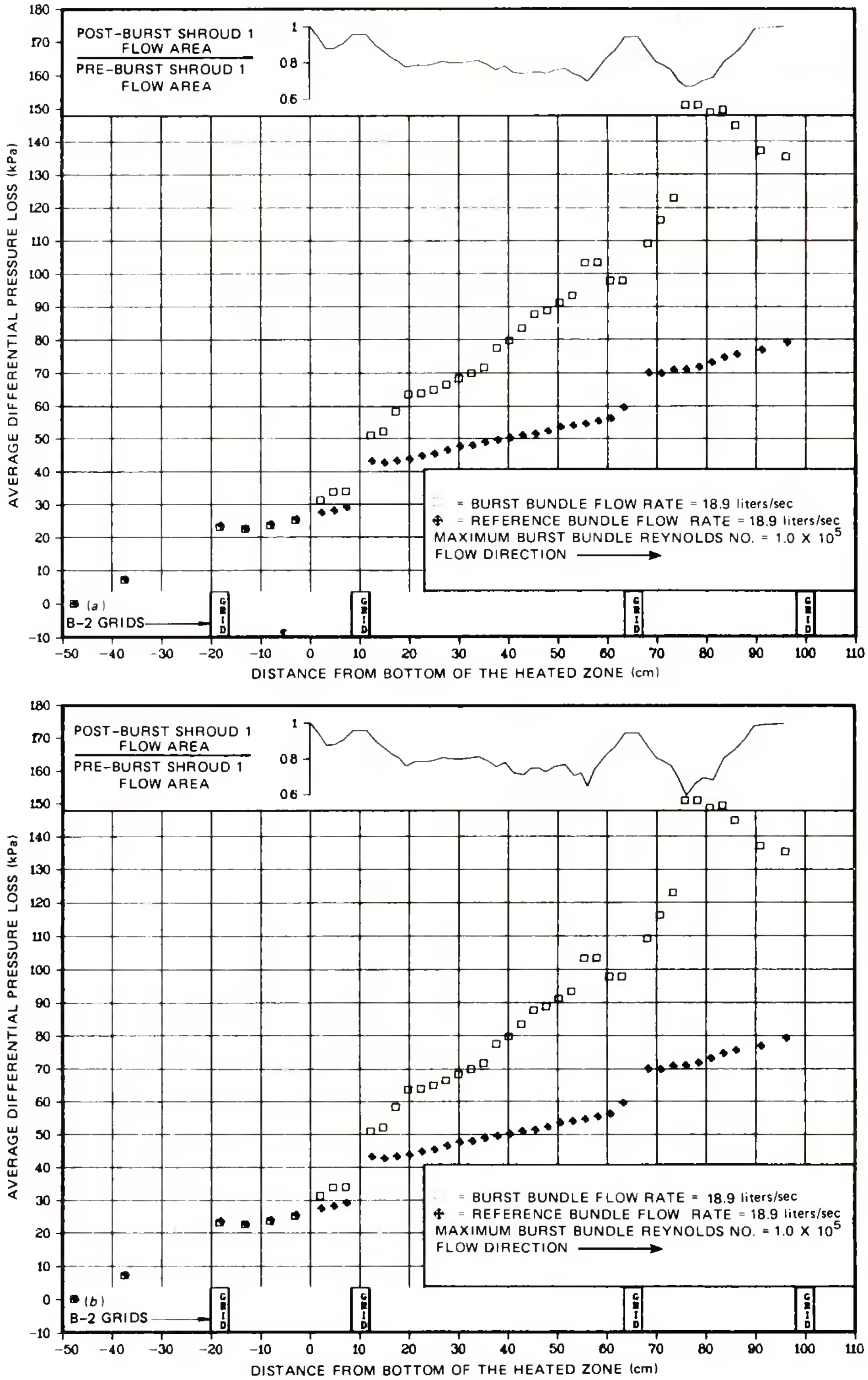



Fig. 3.36. B-2/shroud 1 and reference bundle/shroud 1 axial pressure loss profiles; burst bundle flow rate = 18.9 liters/sec vs: (a) the minimum B-2 restriction profile (b) the maximum B-2 restriction profile.

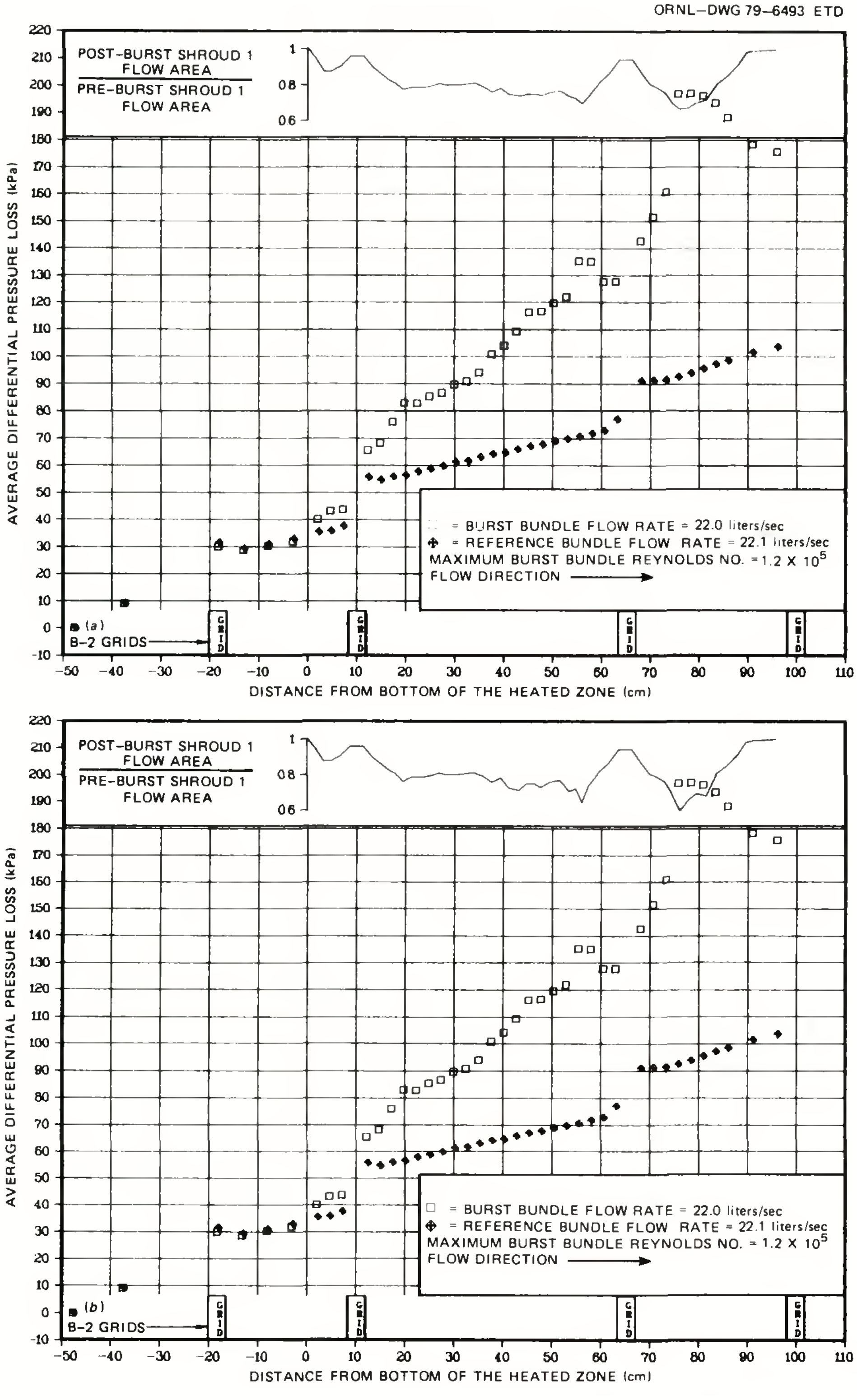



Fig. 3.37. B-2/shroud 1 and reference bundle/shroud 1 axial pressure loss profiles; burst bundle flow rate = 22.0 liters/sec vs: (a) the minimum B-2 restriction profile (b) the maximum B-2 restriction profile.

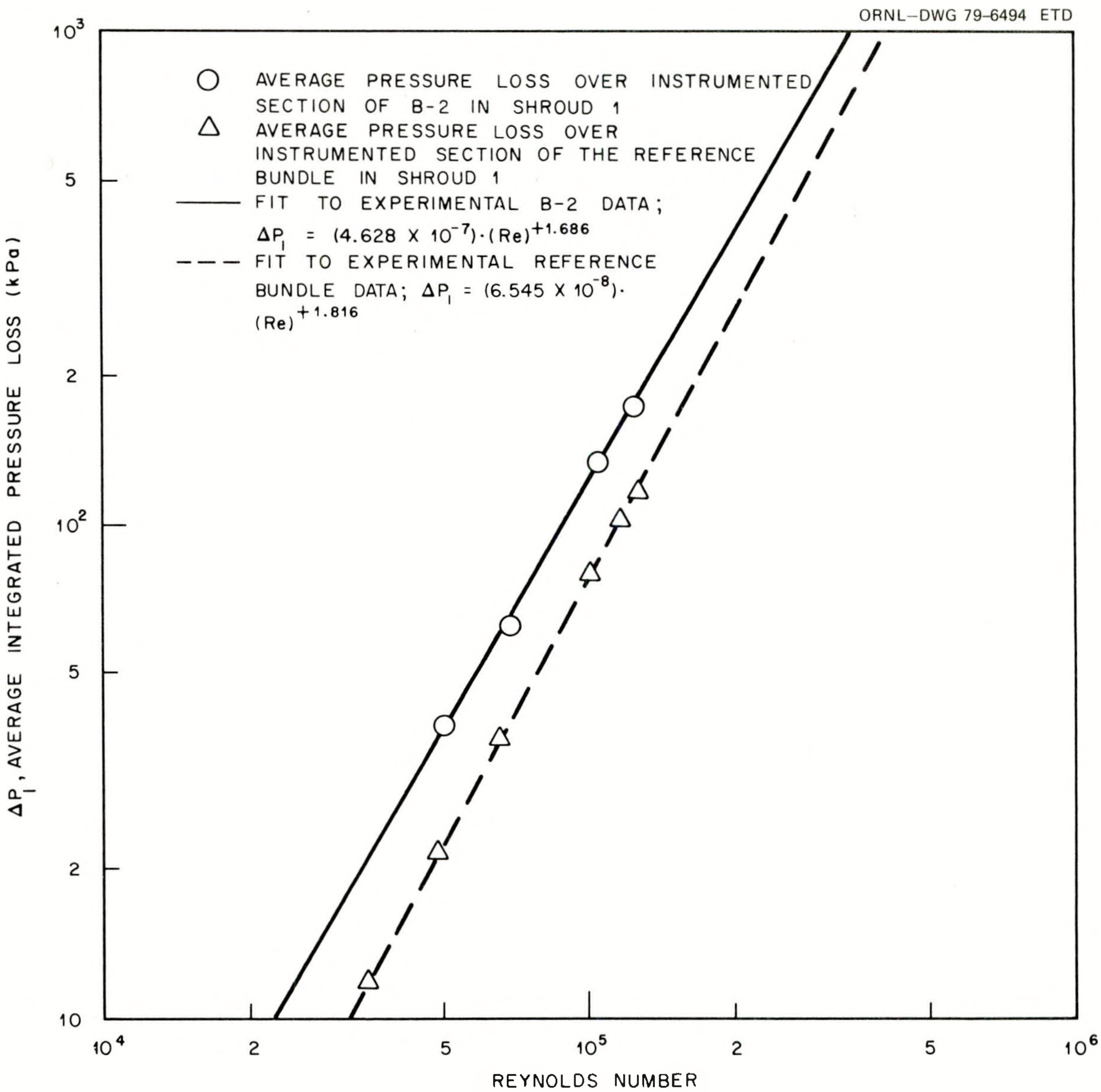



Fig. 3.38. Average integrated pressure losses vs Reynolds number for the B-2 and reference bundle tests in shroud 1. (Note: The Reynolds numbers used to generate this plot were not limited to two significant figures in contrast with the previously reported values.)

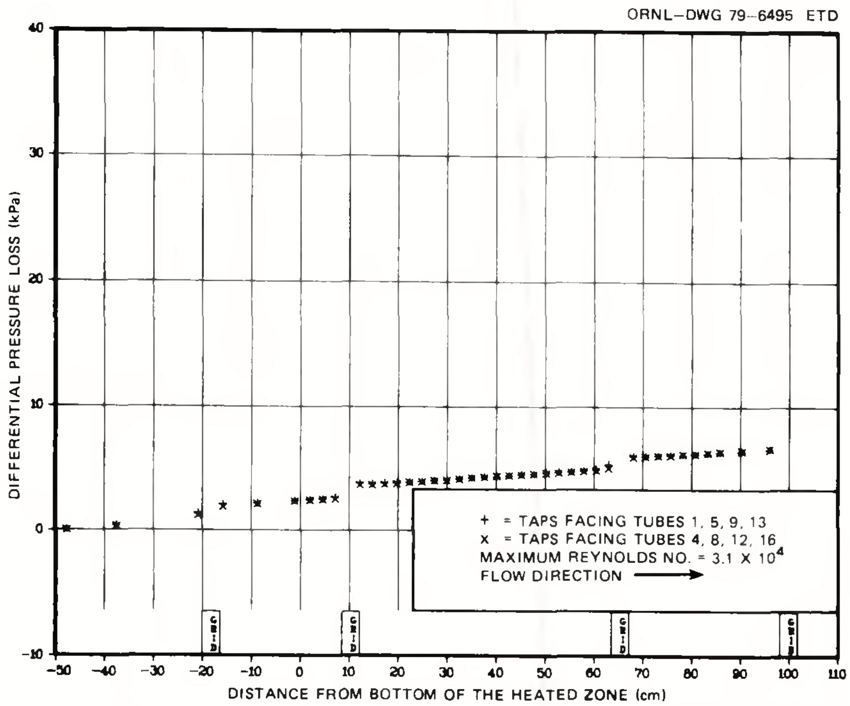



Fig. 3.39. Reference bundle/shroud 2 axial pressure loss profiles; flow rate = 6.31 liters/sec.

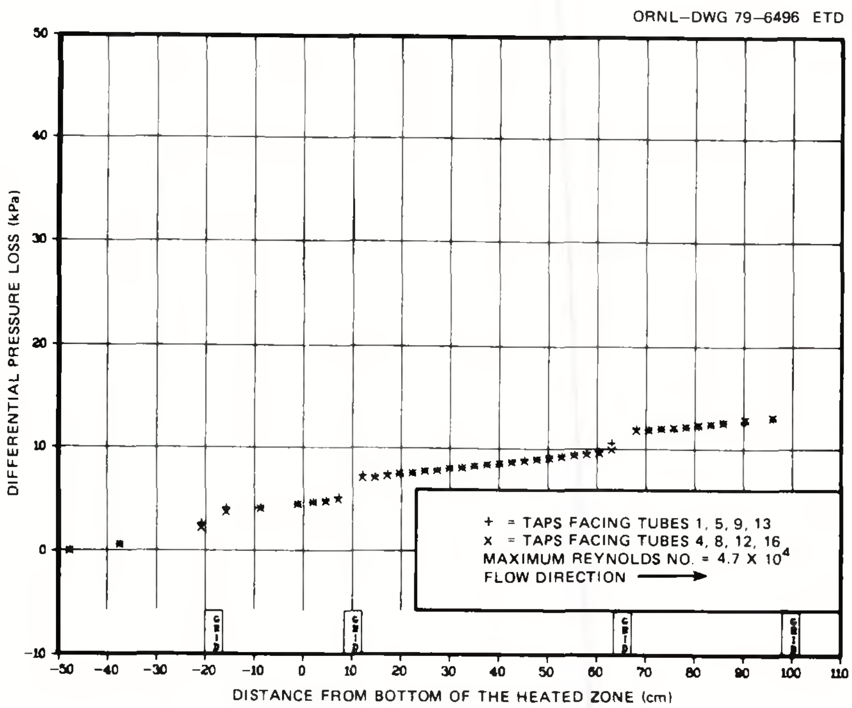



Fig. 3.40. Reference bundle/shroud 2 axial pressure loss profiles; flow rate = 9.45 liters/sec.

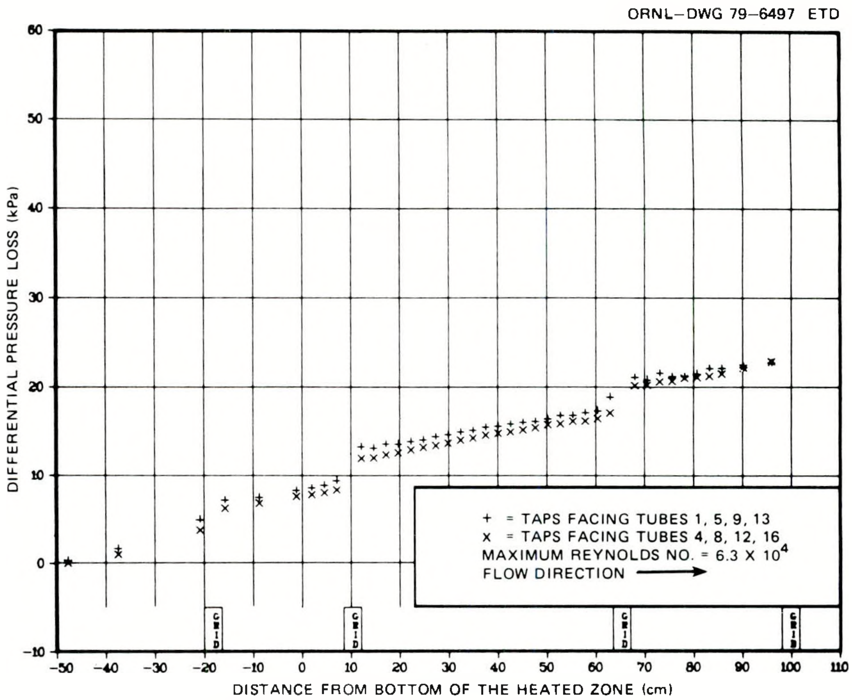



Fig. 3.41. Reference bundle/shroud 2 axial pressure loss profiles; flow rate = 12.8 liters/sec.

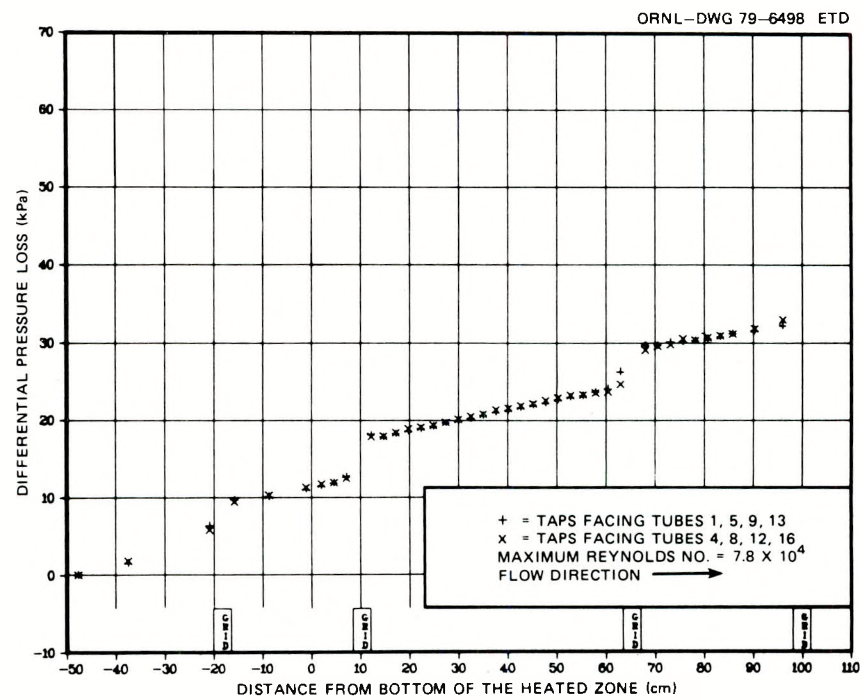



Fig. 3.42. Reference bundle/shroud 2 axial pressure loss profiles; flow rate = 15.7 liters/sec.

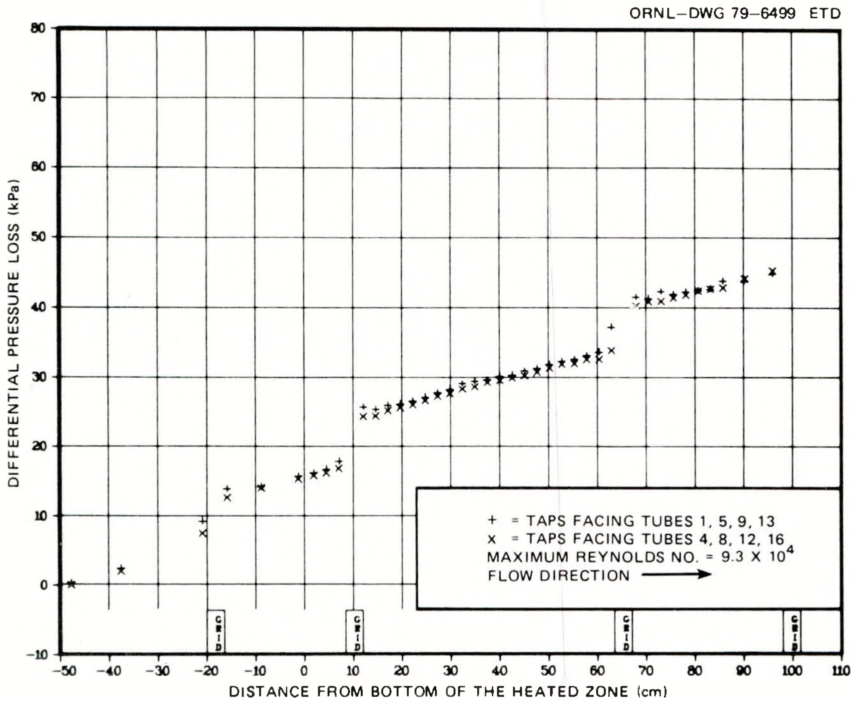



Fig. 3.43. Reference bundle/shroud 2 axial pressure loss profiles; flow rate = 18.9 liters/sec.

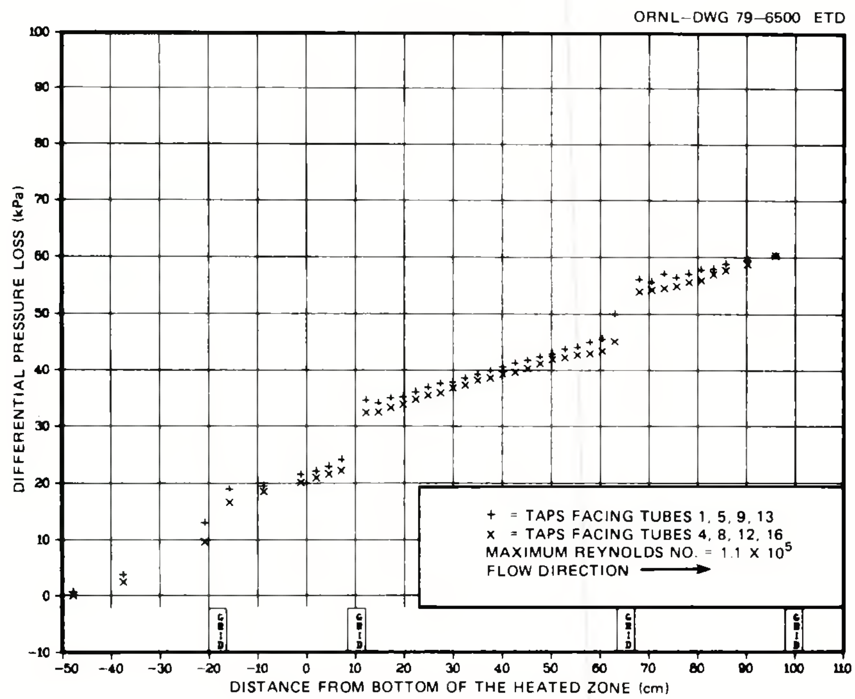



Fig. 3.44. Reference bundle/shroud 2 axial pressure loss profiles; flow rate = 22.0 liters/sec.

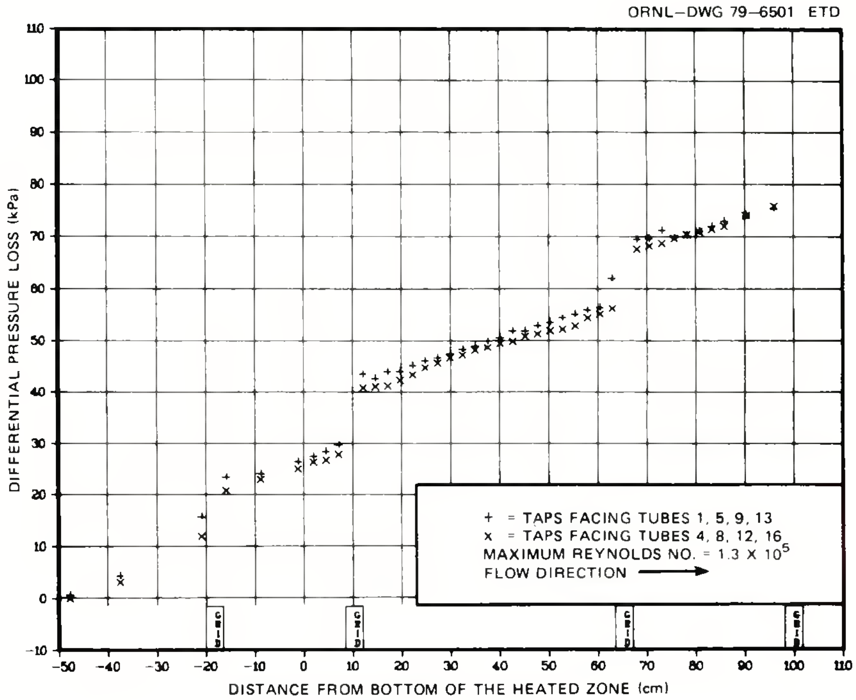



Fig. 3.45. Reference bundle/shroud 2 axial pressure loss profiles; flow rate = 25.3 liters/sec.

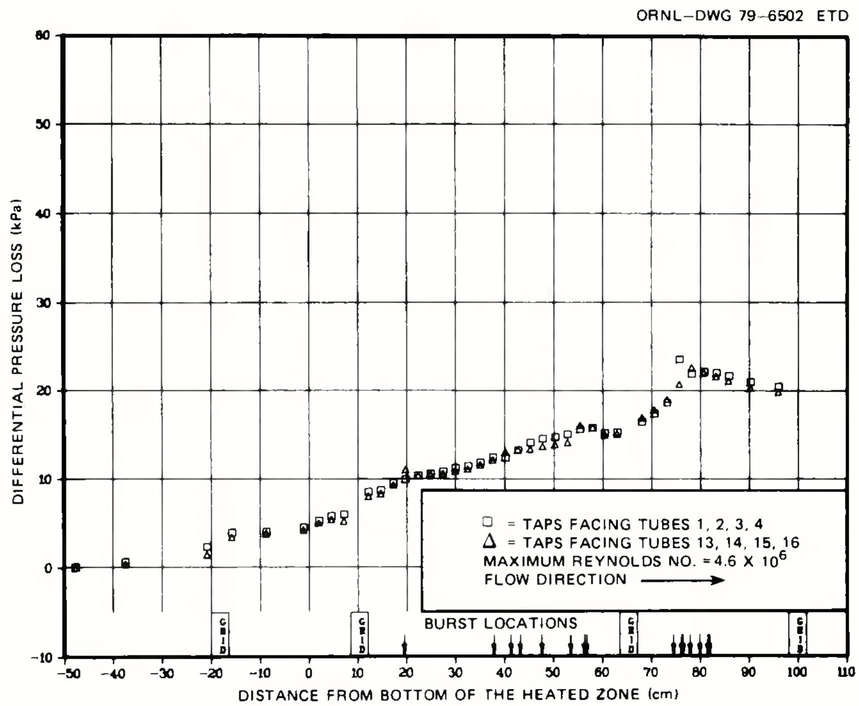



Fig. 3.46. B-2/shroud 2 axial pressure loss profiles; flow rate = 9.47 liters/sec.

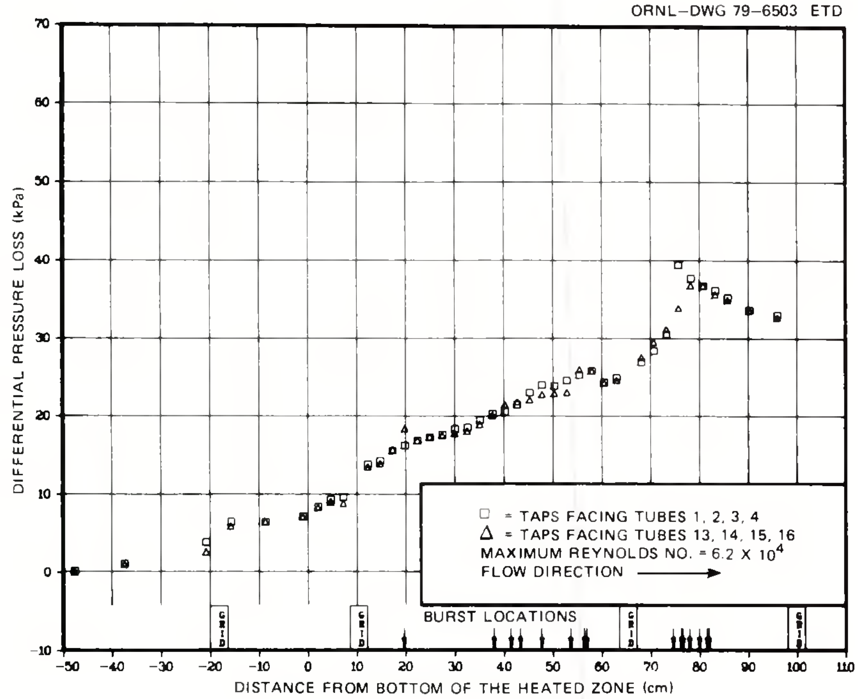



Fig. 3.47. B-2/shroud 2 axial pressure loss profiles; flow rate = 12.5 liters/sec.

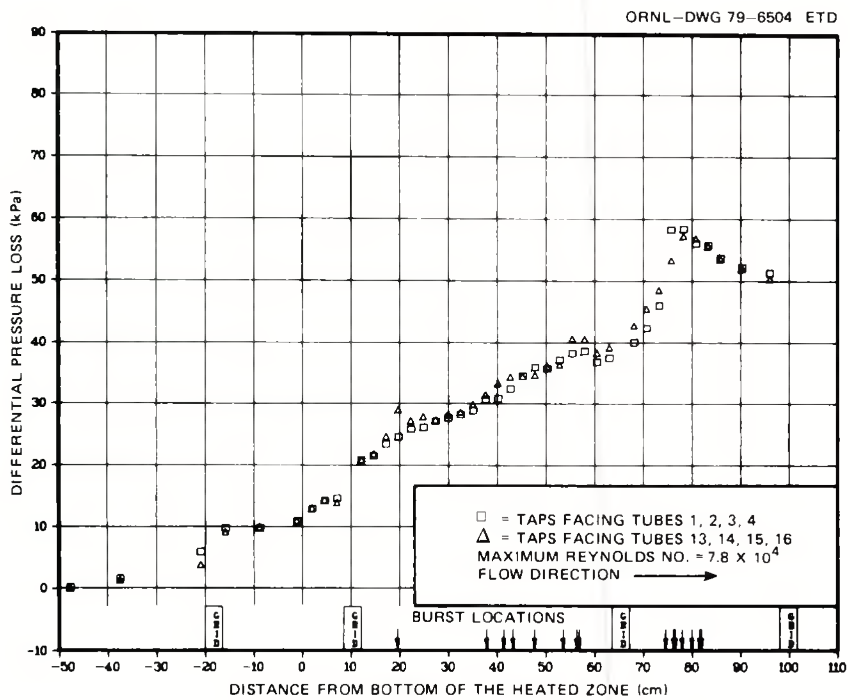



Fig. 3.48. B-2/shroud 2 axial pressure loss profiles; flow rate = 15.8 liters/sec.

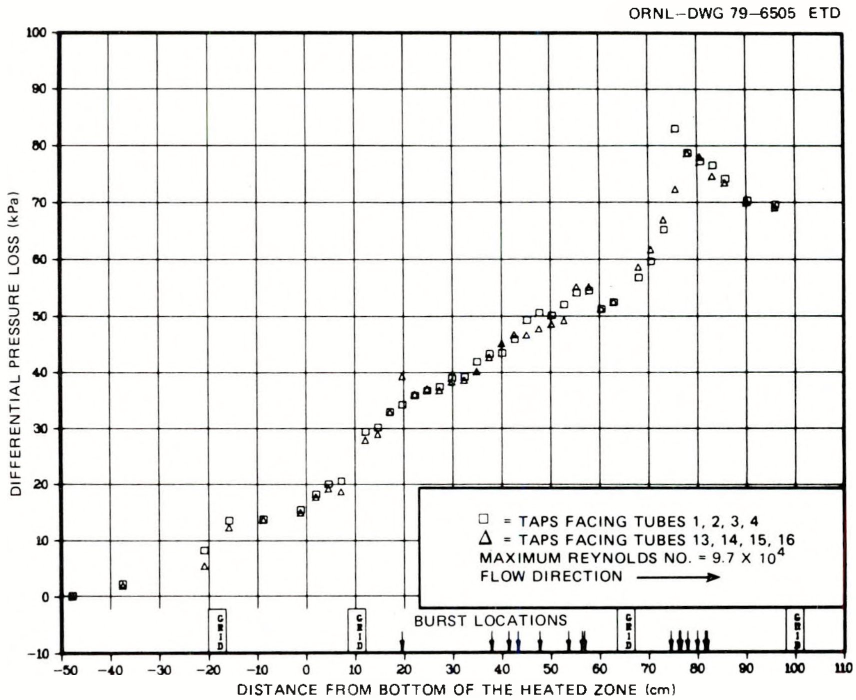



Fig. 3.49. B-2/shroud 2 axial pressure loss profiles; flow rate = 19.0 liters/sec.

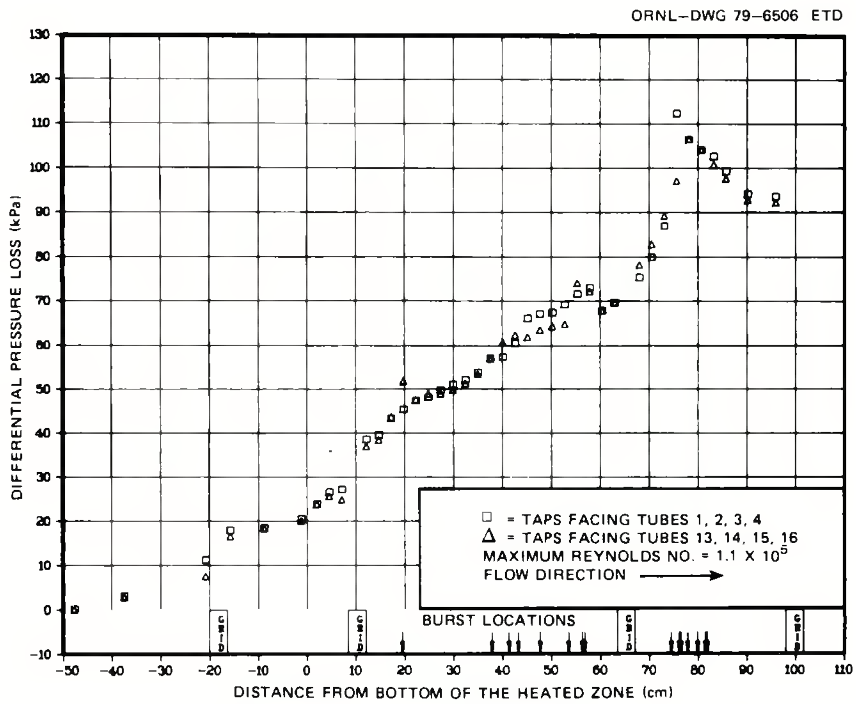



Fig. 3.50. B-2/shroud 2 axial pressure loss profiles; flow rate = 22.2 liters/sec.

ORNL-DWG 79-6507 ETD

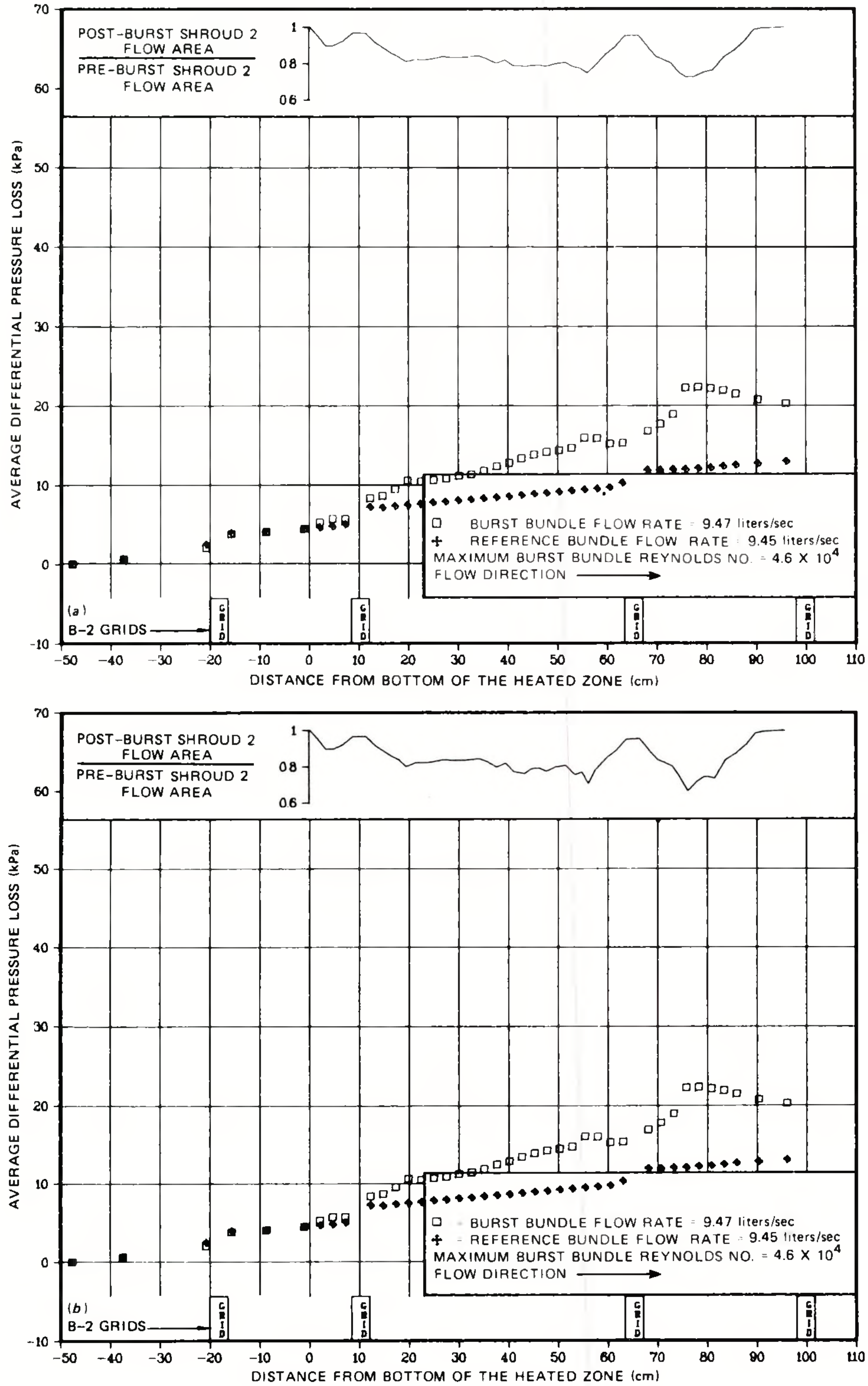



Fig. 3.51. B-2/shroud 2 and reference bundle/shroud 2 axial pressure loss profiles; burst bundle flow rate = 9.47 liters/sec vs: (a) the minimum B-2 restriction profile (b) the maximum B-2 restriction profile.

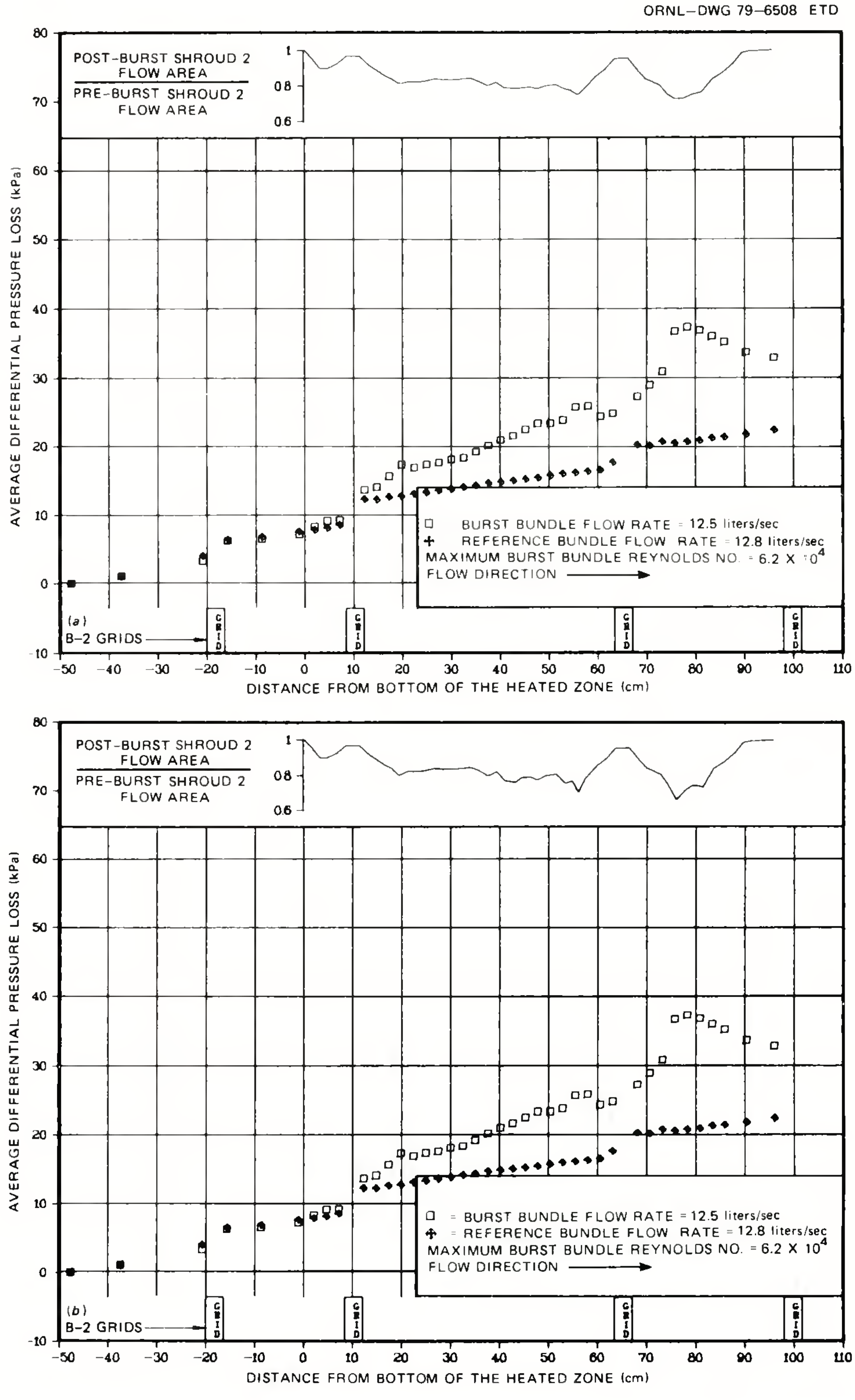



Fig. 3.52. B-2/shroud 2 and reference bundle/shroud 2 axial pressure loss profiles; burst bundle flow rate = 12.5 liters/sec vs: (a) the minimum B-2 restriction profile (b) the maximum B-2 restriction profile.

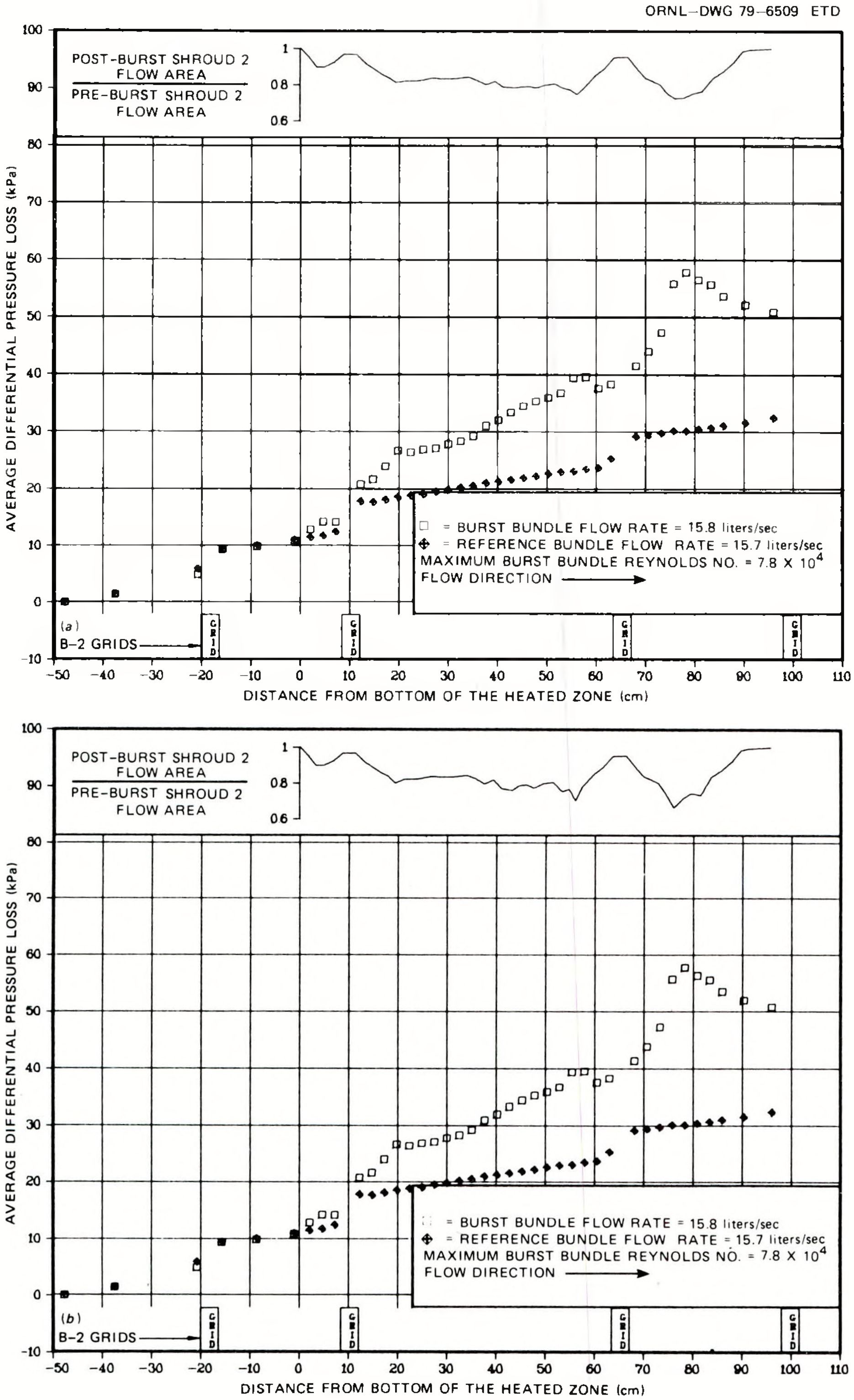



Fig. 3.53. B-2/shroud 2 and reference bundle/shroud 2 axial pressure loss profiles; burst bundle flow rate = 15.8 liters/sec vs: (a) the minimum B-2 restriction profile (b) the maximum B-2 restriction profile.

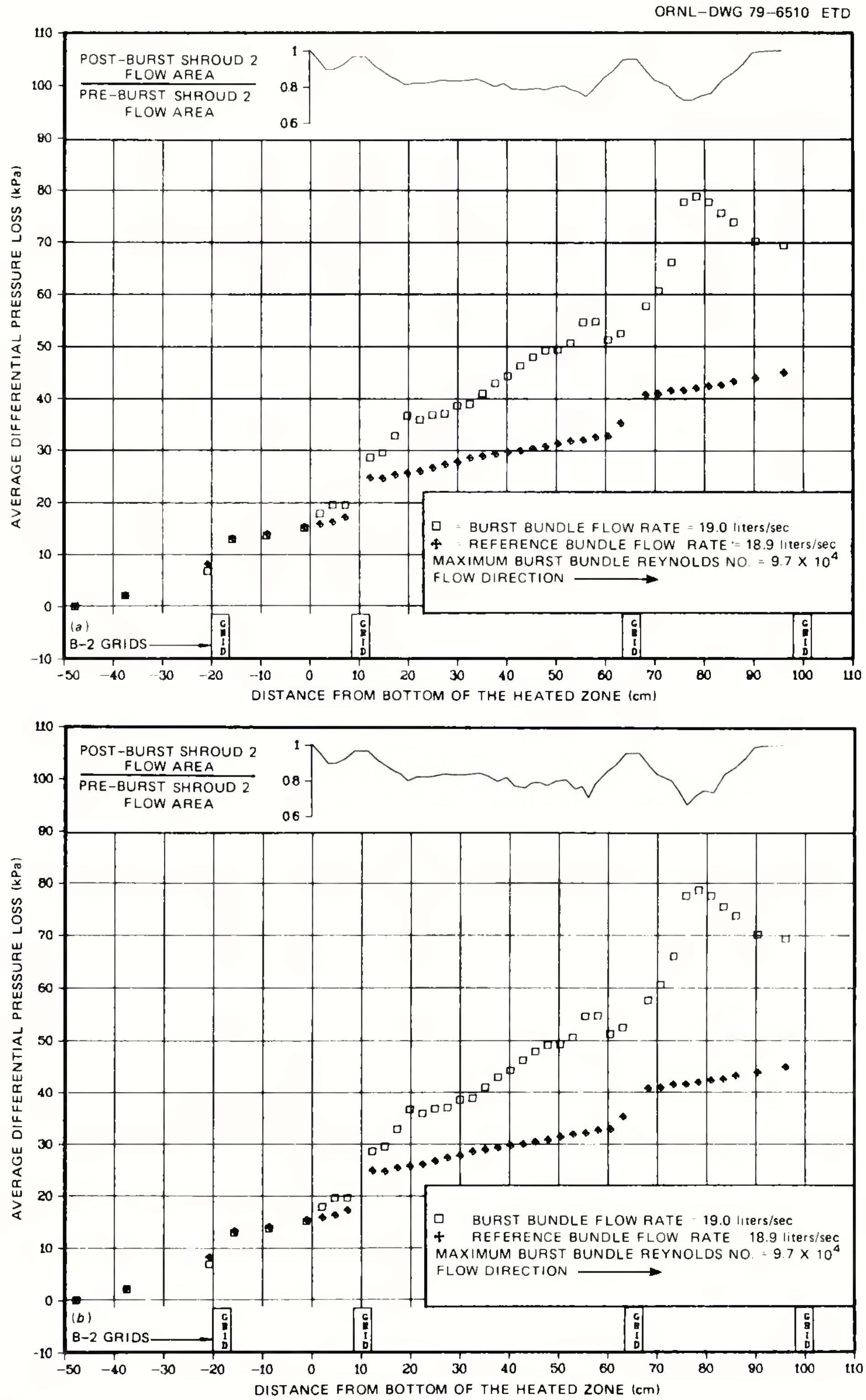



Fig. 3.54. B-2/shroud 2 and reference bundle/shroud 2 axial pressure loss profiles; burst bundle flow rate = 19.0 liters/sec vs: (a) the minimum B-2 restriction profile (b) the maximum B-2 restriction profile.

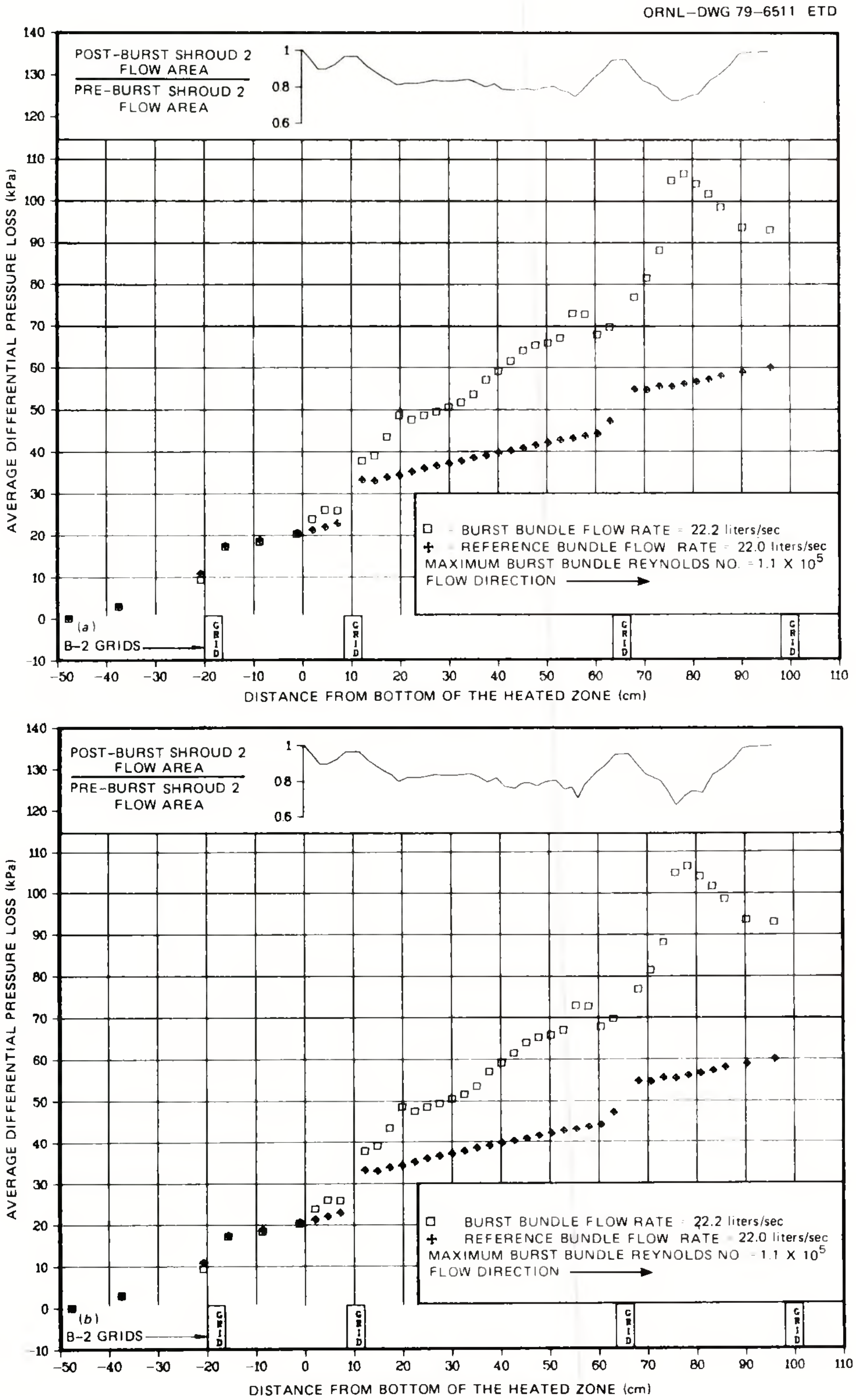



Fig. 3.55. B-2/shroud 2 and reference bundle/shroud 2 axial pressure loss profiles; burst bundle flow rate = 22.2 liters/sec vs: (a) the minimum B-2 restriction profile (b) the maximum B-2 restriction profile.

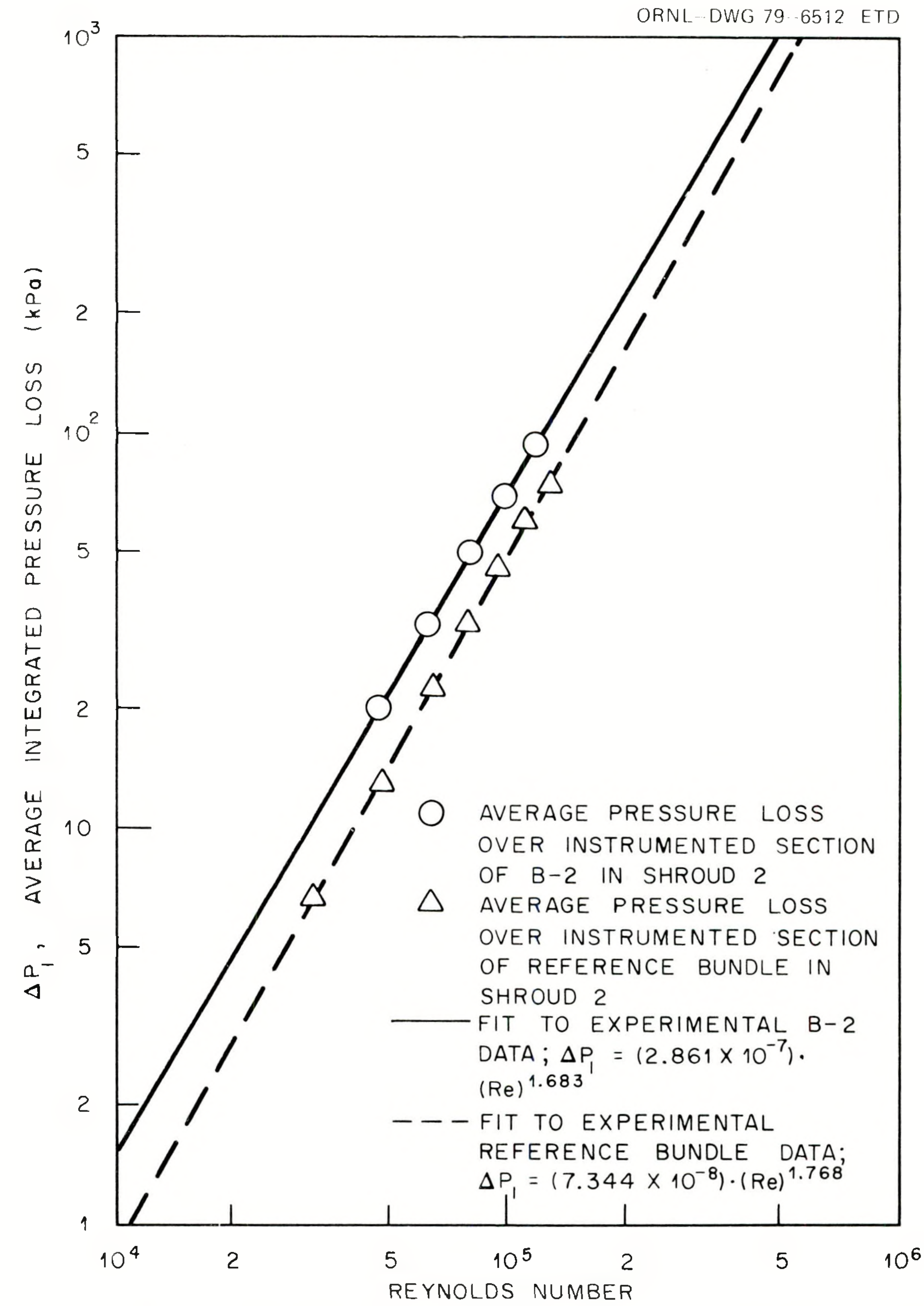



Fig. 3.56. Average integrated pressure losses vs Reynolds number for the B-2 and reference bundle tests in shroud 2. (Note: The Reynolds numbers used to generate this plot were not limited to two significant figures in contrast with the previously reported values.)

# 4. COBRA-IV COMPUTATIONAL MODELS

The MRBT flow tests were conducted with the goal of conforming to the benchmark experiment philosophy: they were experimentally well-defined (as much as equipment limitations allowed) and hydraulically similar, but not necessarily physically identical, to a class of LOCA conditions. By mathematically modeling these experimental data, one can obtain some idea of a particular model's ability to predict pressure losses for systems that are hydraulically similar and more representative of reactor systems. The COBRA-IV thermal-hydraulics code[2] was chosen for the following reasons: (1) the widespread usage and acceptance of the COBRA codes; (2) their capability for handling severe flow restrictions; and (3) the ease with which the empirical correlations used as input can be modified.

## 4.1 Sensitivity Studies

The first step taken in developing the computer models was to conduct a sensitivity study, using various values for the COBRA-IV input parameters which govern the dynamics of the numerical computational schemes. These studies were conducted for the reference and B-2 bundle geometries in shroud 1. The findings indicated that while some slight improvements (computational time savings) are possible without affecting the accuracy of calculated pressures, the default values are generally quite adequate.

The card group 9 COBRA-IV parameters which do affect calculated pressure losses are somewhat self-evident. Briefly, the bundle orientation (THETA in card group 9), the fluid temperature, the flow rate, the flow geometry, the grid spacer pressure loss coefficient, and the friction factor correlation were found to be important. As pointed out in Sect. 2.1, the flow test equipment was so designed to eliminate the static pressure head contribution (described by THETA) from the measurements. Hence, THETA was set equal to 90° from vertical to preclude this type of contribution from piezometric pressures calculated by COBRA-IV. The fluid temperature and flow rate parameters are, of course, dependent upon data measured for each test.

## 4.2 Bundle-Averaged Geometries

Figures 4.1 and 4.2 show COBRA-IV models of the reference bundle/shroud 1 and reference bundle/shroud 2 assemblies. To calculate burst bundle geometries with COBRA-IV, card groups 5 and 6 require subchannel area and gap ratios relating burst to reference bundle values by axial bundle level. The preparation of card group 5 and 6 data could conceivably become very involved if burst bundle geometries had to be exactly modeled in terms of individual subchannel restrictions and gap variations. Instead of taking this route, a bundle-averaged approach was adopted in producing the calculational results given in this report.

The subchannel restrictions, denoted as AFACT data in ref. 2, were calculated with the following formula:

$$AFACT_{zi} = \frac{C_{zi} + \left[ A_o - \left( \sum_{j=1}^{16} AF_{jz} \right) \Big/ 16 \right] F_i}{C_{zi}} , \tag{4.1}$$

where

$C_{zi}$ = undeformed-bundle subchannel i flow area at elevation z,

$A_o$ = cross-sectional area occupied by an undeformed-bundle tube,

$AF_{jz}$ = cross-sectional area occupied by the deformed-bundle tube j at elevation z,

$F_i$ = fraction of one tube area which occupies subchannel i before the burst test (1/4, 1/2, or 1).

The $C_{zi}$ parameter used for modeling tests in shroud 1 included the appropriate relief groove (see Fig. 2.6) contributions to the subchannel areas.

This formulation essentially calculates an average tube area based on the 16 measured tube areas per axial level. This average tube area then replaces each of the 16 tubes when calculating AFACT values for the 25 subchannels. Consequently, AFACT data generated in this way represent a smeared or bundle-averaged restriction, which preserves the gross flow channel area but ignores the twists and turns individual tubes might make in and out of the surrounding subchannels.

The deformed-to-undeformed gap ratios, or GFACT (ref. 2) data, were computed with the following formula:

$$GFACT_{zk} = \left\{ \frac{2G_{zk} - \left[ \sqrt{\left( \sum_{j=1}^{16} AF_{jz} \right) / \pi} \right] P_k}{2G_{zk} - \left[ 4\sqrt{(A_o/\pi)} \right] P_k} \right\} \qquad (4.2)$$

(if the formula above yields a negative value, $GFACT_{zk} = 0$),

where

$G_{zk}$ = distance from the undeformed tube center to the adjacent tube center or shroud wall for gap k at elevation z,

$P_k$ = 1/2 for the 16 gaps between the tubes and shroud, 1 for the 24 tube-to-tube gaps.

This formulation calculates an average burst tube area based on the 16 tube areas at a given axial location, as was done for generating AFACT data. The radius of this average burst tube area is then determined and used to generate the GFACT data corresponding to the 40 gaps per axial location. No corrections to GFACT data were made to reflect the presence of shroud 1 relief grooves. AFACT and GFACT data for the B-1 and B-2 COBRA-IV models may be found in Appendices A through F.

## 4.3 Grid Spacer Pressure Loss Coefficients

COBRA-IV requires as input an effective grid spacer loss coefficient, $K_c$, implicitly defined in the following formula:

$$\Delta P_s = \left( \frac{K_c}{2\rho g_c} \right) \left( \frac{M}{A_f} \right)^2 , \qquad (4.3)$$

where

$\Delta P_s$ = nonrecoverable pressure loss induced by the grid spacer,

$K_c$ = COBRA-IV spacer loss coefficient,

$\rho$ = fluid density,

$g_c$ = a unit conversion factor,

$M$ = fluid mass flow rate,

$A_f$ = total flow area upstream of the grid spacer.

Using an alternate formulation by de Stordeur,[6] a drag coefficient, $C_s$, is implicitly defined:

$$\Delta P_s = \left(\frac{C_s}{2\rho g_c}\right)\left(\frac{1 - \sigma}{\sigma^2}\right)\left(\frac{M}{A_f}\right)^2 , \qquad (4.4)$$

where $C_s$ is the spacer drag coefficient and $\sigma$ is the ratio of the flow area in the spacer grid region to $A_f$. Equating Eqs. (4.3) and (4.4), $K_c$ may be expressed as

$$K_c = C_s \left(\frac{1 - \sigma}{\sigma^2}\right). \qquad (4.5)$$

The determination of $K_c$ then hinges on knowing $\sigma$ for the system under investigation.

For MRBT reference bundle flow tests, the projected grid frontal area [= $A_f(1 - \sigma)$] was estimated to be 3.8 ± 0.6 $cm^2$ by means of linear measurements. The single-grid flow tests (Sects. 3.1 and 3.2) indicated this value to be more on the order of 5.8 ± 0.2 $cm^2$ (based on COBRA-IV data fits to be discussed later). This discrepancy is the result of uncertainties induced by miscellaneous features on the spacer grids such as welding beads, dimples, etc. As the determination of frontal areas for such features is difficult, the approach using linear grid dimensions (metal thicknesses and lengths) understandably underestimated the total effective frontal area of the grid. The determination of an effective projected grid frontal area (5.8 ± 0.2 $cm^2$) derived from the single-grid flow test data circumvents this difficulty and is believed to be a more accurate representation.

Based on the $5.8 \pm 0.2$ cm$^2$ area, values of $\sigma$ may be calculated for reference bundle/shroud geometries. For shroud 1, $\sigma$ is estimated to be $0.82 \pm 0.02$. Values for $K_c$ may be estimated, using a value of 1.7 (see ref. 5) for $C_s$ [Eq. (4.5)]. For shroud 1, $K_c = 0.53 \pm 0.07$; for shroud 2, $K_c = 0.46 \pm 0.07$. As will be shown in Chap. 5, these values were found to be in good agreement with most of the flow test data.

## 4.4 Friction Factor Correlations

A similar empirical approach was taken in determining an appropriate friction correlation for the turbulent friction factor. After finding a fairly good estimate for the spacer loss coefficient via the second single-grid test series, the turbulent friction factor correlation was varied in the COBRA-IV single-grid test models until good agreement was achieved between calculational and experimental pressure loss profiles. This topic will be discussed in more detail later in Chap. 5.

McAdams[7] proposed the following correlation, which approximates the Darcy-Weisbach friction factor, f, for turbulent flow in smooth tubes:

$$f = 0.184(Re)^{-0.2} \text{ for } 3 \times 10^4 < Re < 2 \times 10^6 \text{ .} \qquad (4.6)$$

Because MRBT flow tests involved flow exterior to tube bundles, some modifications to the Darcy-Weisbach factor for flow inside a smooth-walled tube are required to represent bundle frictional flow losses. Data given by Tong,[8] though inconclusive, indicate that the reference (preburst) MRBT bundle's pitch-to-diameter ratio of 1.32 reflects about a 30% increase in the smooth-tube Darcy-Weisbach friction factor. A more detailed study by Marek, Maubach, and Rehme[9] suggests only a 6% increase. As will be shown in Chap. 5, the correlations chosen for MRBT COBRA-IV models reflect increases on the order of 20 to 30%. For both shrouds and all bundles, the following modified McAdams correlation was found to fit well:

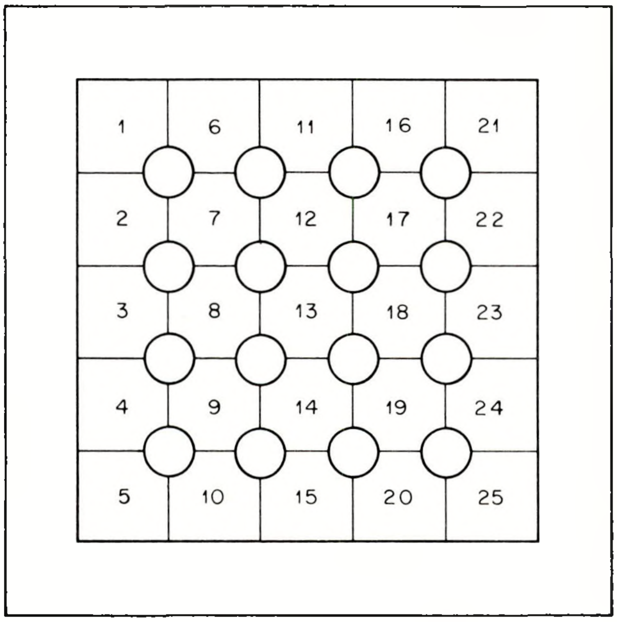
$$f = (0.225 \pm 0.010)(Re)^{-0.2} \text{ for } 3 \times 10^4 < Re < 2 \times 10^6 \text{ .} \qquad (4.7)$$

## 4.5 Summary

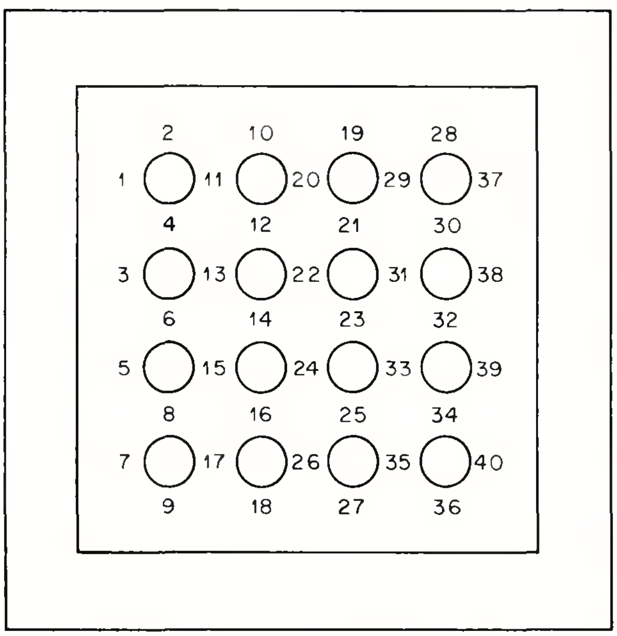
Two points should be reiterated concerning the COBRA-IV models. The first is the use of bundle-averaged geometry representations for burst bundles, a practice which considerably simplified COBRA-IV input preparation. The validity of this approximation will be demonstrated when computational and experimental pressure loss profiles are compared in Chap. 5.

The second point is the fact that uncertainties in reported experimental data (especially flow rates), friction factors, and spacer loss coefficients are intertwined; hence, the friction factors and spacer loss coefficients cannot be determined any more precisely than experimental precision limits allow. This point must be kept in mind when comparing friction factor correlations and spacer loss coefficients found in the literature with those used for COBRA-IV MRBT models.

ORNL-DWG 79-6513 ETD




| SUBCHANNEL NUMBER | SUBCHANNEL AREA* ($cm^2$) |
|---|---|
| 1, 5, 21, 25 | 1.045 |
| 2, 3, 4, 22, 23, 24 | 1.357 |
| 6, 10, 11, 15, 16, 20 | 0.990 |
| 7, 8, 9, 12, 13, 14, 17, 18, 19 | 1.145 |

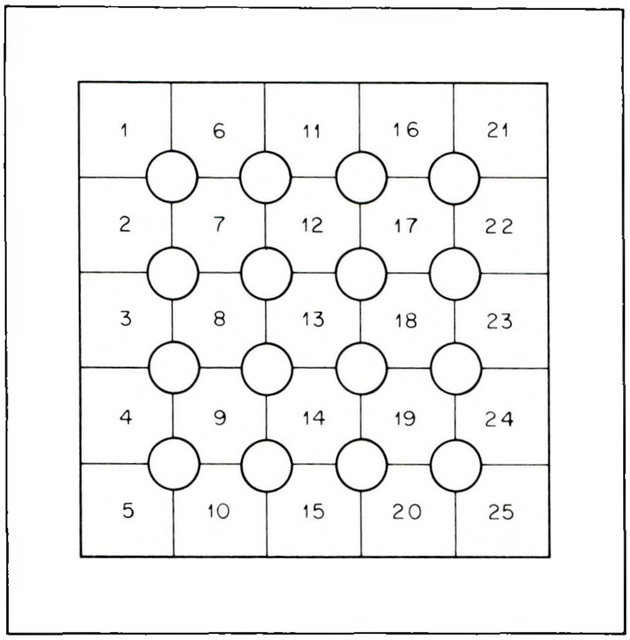



| GAP NUMBER | GAP WIDTH* (cm) |
|---|---|
| 1, 3, 5, 7, 37, 38, 39, 40 | 0.719 |
| 2, 9, 10, 18, 19, 27, 28, 36 | 0.465 |
| 4, 6, 8, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 29, 30, 31, 32, 33, 34, 35 | 0.351 |

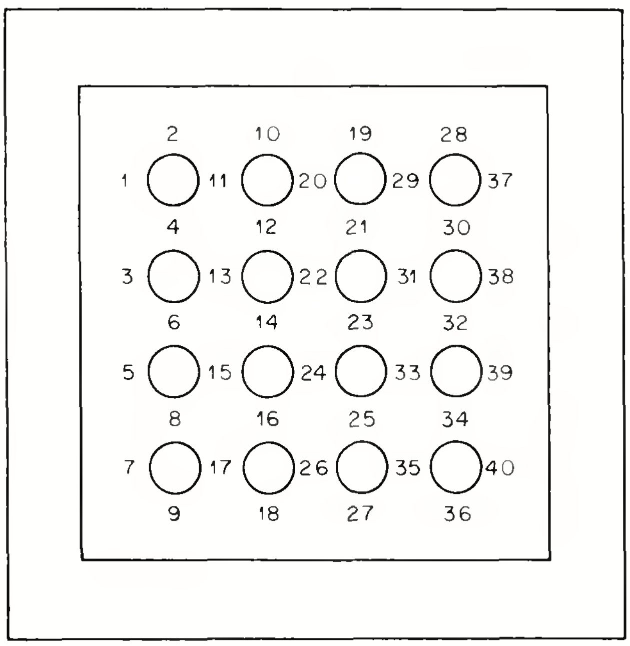
*FOR REGIONS AWAY FROM SHROUD DEFORMITIES IN SUBCHANNELS 1, 5, 6, 10, 11, 15, AND 20

Fig. 4.1. COBRA-IV model of the reference bundle in shroud 1; subchannel and gap dimensions.

ORNL–DWG 79–6514 ETD




| SUBCHANNEL NUMBER | SUBCHANNEL AREA ($cm^2$) |
|---|---|
| 1, 5, 21, 25 | 1.581 |
| 2, 3, 4, 22, 23, 24 | 1.503 |
| 6, 10, 11, 15, 16, 20 | 1.448 |
| 7, 8, 9, 12, 13, 14, 17, 18, 19 | 1.145 |




| GAP NUMBER | GAP WIDTH (cm) |
|---|---|
| 1, 3, 5, 7, 37, 38, 39, 40 | 0.820 |
| 2, 9, 10, 18, 19, 27, 28, 36 | 0.782 |
| 4, 6, 8, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 29, 30, 31, 32, 33, 34, 35 | 0.351 |

Fig. 4.2. COBRA-IV model of the reference bundle in shroud 2; subchannel and gap dimensions.

# 5. COMPARISONS BETWEEN EXPERIMENTAL AND COMPUTATIONAL RESULTS

In this chapter, the data generated with the previously described COBRA-IV models are compared with the experimental data presented in Chap. 3. An attempt has been made to arrange these analyses such that all calculational and experimental data available for a particular comparison are generally presented in the same figure; comparisons with calculational results based on different friction factors and spacer loss coefficients will be denoted "a," "b," or "c." The figure numbers are arranged in order of ascending flow rates. The Reynolds numbers reported in these figures are based solely on the reported experimental flow rates, temperature, and flow area data, as discussed in Chaps. 2 and 3.

## 5.1 First Single-Grid Tests in Shroud 1

Averaged experimental flow test data from the first single-grid tests in shroud 1 are compared with COBRA-IV bundle-averaged pressure loss calculations in Figs. 5.1 through 5.6. The "a" comparisons reflect COBRA-IV bundle-averaged pressure losses based on a friction factor correlation of $0.220(Re)^{-0.2}$ and a grid spacer pressure loss coefficient of 0.50. The "b" comparisons represent calculations performed with a friction factor correlation of $0.235(Re)^{-0.2}$ and a grid loss coefficient of 0.60.

As shown in these figures, the COBRA-IV calculations based on the $0.235(Re)^{-0.2}$ friction factor correlation and 0.60 grid loss coefficient agree significantly better with the experimental data. The flow rates used for these calculations are +3% to +1% above the reported experimental values. This discrepancy is the result of a deliberate effort to determine the minimum best-fit values for friction factors and grid loss coefficients based on the effects of reasonable uncertainties (see Sect. 2.4) in the reported experimental flow rates. Hence, the "b" friction factor correlation and grid spacer loss coefficient represent approximate minimum limits on these empirical quantities for good agreement with COBRA-IV pressure loss calculations. The nonlinearities downstream of the spacer grid and 65 cm discussed in Sect. 3.1 are very evident in Fig. 5.6b.

## 5.2 Second Single-Grid Tests in Shroud 1

Figures 5.7 through 5.12 present a similar analysis for the second single-grid test experimental data. Again the "b" comparisons with COBRA-IV bundle-averaged pressures based on a $0.235(Re)^{-0.2}$ friction factor correlation and a 0.60 grid loss coefficient match the experimental data significantly better than the "a" comparisons. Note that, for these calculations, flow rates were closely matched, unlike the first single-grid test series. Hence, the $0.235(Re)^{-0.2}$ friction factor and 0.60 grid loss coefficient are evidently good representations for the two single-grid test series.

The nonlinearity downstream of 65 cm is again visible (see Fig. 5.12b). However, the disturbed zone downstream of the grid in these tests is almost nonexistent relative to effects seen in Fig. 5.6b. No good explanation exists at present for this anomaly. Finally, Fig. 5.12b indicates that while some flow rate drifting occurred (see Sect. 3.2), COBRA-IV results still match experimental pressure loss data reasonably well and in a manner consistent with the other second single-grid flow tests.

## 5.3 Reference Bundle Tests in Shroud 1

Figures 5.13 through 5.18 compare COBRA-IV-derived pressure loss profiles with the corresponding experimental data presented in Sect. 3.3. As noted earlier, the "a" comparisons use a friction correlation of $0.220(Re)^{-0.2}$ compared with $0.235(Re)^{-0.2}$ for the "b" comparisons and a grid coefficient of 0.50 compared with 0.60 for "b". As shown, the calculated pressure loss profiles using both friction factor correlations and grid loss coefficients tend to overestimate the experimental pressure loss profiles, especially at the higher flow rates. If the "a" comparisons are examined more closely, it can be seen that the discrepancies between calculated and experimental pressure loss profiles could be explained by about a 3% decrease in the reported volumetric flow rates. Hence, the $0.220(Re)^{-0.2}$ friction factor and 0.50 grid loss coefficient fit the experimental results better than the "b" correlations and represent approximate maximum correlation limits, as the discrepancies in "a" data might be explained in terms of the lower-bound precision limits of the experimental data. This finding is inconsistent with the minimum best-fit correlations recommended for the single-grid test data, the "b" values; that is, the maximum "a" correlations are lower in magnitude than the minimum single-grid values.

### 5.4 B-1 Tests in Shroud 1

Because of the wide range of variation in friction factor correlations and grid loss coefficients which best fit the reference and single-grid experimental data, no attempt was made to tailor the friction factor correlations to reflect the effect of lower pitch/tube diameter ratios characterizing burst bundles. Instead, the previously used empirical correlations were employed in generating calculated B-1/shroud 1 pressure losses for comparison with experimentally derived data. These comparisons are shown in Figs. 5.19 through 5.22; the calculations used were based on the minimum flow restriction definition (see Sect. 3.4, especially Table 3.1). Similar comparisons, with calculational results based on the maximum flow restriction definition (see Sect. 3.4, especially Table 3.2), are given in Figs. 5.23 through 5.26. As seen, the calculations based on the minimum flow restriction definition appear to fit the experimental pressure loss profiles best. Also evident in Figs. 5.19b and 5.20b is the fact that the $0.235(Re)^{-0.2}$ friction factor correlation and the 0.60 grid loss coefficient represent the better fit to experimental pressure loss profiles up to a $1.28 \times 10^{-2}$ $m^3$/sec flow rate. Above this flow rate, as shown in Figs. 5.21a and 5.22a, the calculations based on the $0.220(Re)^{-0.2}$ friction factor correlation and 0.50 grid loss coefficient represent the better fit with experimental data.

Hence, as was the case in the comparison of COBRA-IV and experimentally derived pressure loss profiles for single-grid and reference bundle tests, no single friction factor correlation or grid loss coefficient was found to be adequate. The fact that the predicted <u>shapes</u> of the pressure loss profiles agree well with experimental data for a judicious choice of friction factor correlations and grid loss coefficients suggests that COBRA-IV provides a very adequate tool for modeling such pressure losses. Difficulties in adjusting absolute values of calculated pressure loss profiles to agree with experimental values are indicative of the precision limits on the experimental data describing the experiment (i.e., fluid temperatures, flow rates, and flow areas) and not of COBRA-IV limitations.

## 5.5 B-2 Tests in Shroud 1

Comparisons of COBRA-IV and experimental pressure loss profiles were made for the B-2/shroud 1 flow tests. These comparisons are shown in Figs. 5.27 through 5.30; the calculational results are based on the minimum restriction definition (see Table 3.3) and the two previously used correlation sets. Similar comparisons based on the maximum restriction definition (see Table 3.4) for B-2 tube areas are shown in Figs. 5.31 through 5.34.

Determining which restriction definition produces COBRA-IV pressure loss profiles that are more representative of experimentally derived data is impossible. This dilemma results from the fact that both restriction definitions are virtually identical except around 42 and 76 cm above the bottom of the heated zone. The differences at 42 cm between the calculated profiles based on these two definitions and the experimental data are inconsequential. On the other hand, both definitions underestimate the experimental data at 76 cm. As stated in Sect. 3.5, there is reason to believe that the experimental data in the 76-cm region are invalid — it is suspected that they do not strictly represent piezometric pressures. Hence, no determination can really be made as to the better restriction definition.

One may conclude, however, that once again no single best correlation for the friction factor or grid loss coefficient can be established. As shown in Figs. 5.27 and 5.31, the calculational data based on the $0.235(\mathrm{Re})^{-0.2}$ friction factor correlation and 0.60 grid loss coefficient fit the experimental data best, consistent with the B-1 comparisons at similar Reynolds numbers. At the higher flow rates, the alternate set of correlations produced results in better agreement with the experimental data, again consistent with the B-1 findings. Hence, for shroud 1, regardless of the bundle, the grid loss coefficients given in Sect. 4.3 and the friction factor correlation given in Sect. 4.4 [Eq. (4.5)] are recommended in conjunction with this data. The particular values chosen (especially for grid coefficients) from these ranges should generally follow this rule-of-thumb: choose larger values for low flow rates and smaller values for higher flow rates. This trend is consistent with behavior observed previously[6] — that is, the observed dependence of grid spacer loss coefficents on Reynolds number.

## 5.6 Reference Bundle Tests in Shroud 2

Similar analyses of reference bundle/shroud 2 tests are found in Figs. 5.35 through 5.41. Three sets of computational results, labeled "a," "b," and "c," are given in each figure, representing three sets of empirical friction factor and grid loss coefficient correlations. The "a" correlations are $0.215(\mathrm{Re})^{-0.2}$ and 0.40 for the friction factor and grid loss coefficient, respectively; the "b" correlations are $0.220(\mathrm{Re})^{-0.2}$ and 0.45; the "c" correlations are $0.235(\mathrm{Re})^{-0.2}$ and 0.50. The friction factor was not expected to be shroud-dependent and, as shown, this proved to be the case. The grid loss coefficient and its estimated uncertainty for shroud 2, derived in Sect. 4.3, were found adequate.

As shown in these and previous figures, the best agreement between calculated and experimental results again occurs when the larger correlation values are used at low flow rates and the smaller values are used at higher flow rates. Overall, the agreement between calculated and experimentally derived results is considered good.

## 5.7 B-2 Tests in Shroud 2

Comparisons of calculated B-2/shroud 2 pressure loss profiles, based on the minimum restriction definition (see Table 3.3), are made with experimental data in Figs. 5.42 through 5.46. Similar comparisons are made of pressure-loss profiles based on the maximum restriction definition (see Table 3.4) in Figs. 5.47 through 5.51. As for the B-2/shroud 1 comparisons, no clear choice can be made as to which restriction definition is the better.

The $0.235(Re)^{-0.2}$ friction factor and 0.50 grid loss correlation results fit better in Figs. 5.42, 5.47, 5.43, and 5.48. The "b" fits were better for 5.44, 5.49, 5.45, and 5.50. The $0.220(Re)^{-0.2}$ friction factor and 0.45 correlation tend to fit better with increasing flow rate magnitudes. This observation is consistent with the earlier rule-of-thumb as to the choice of the empirical correlation values as a function of flow rate.

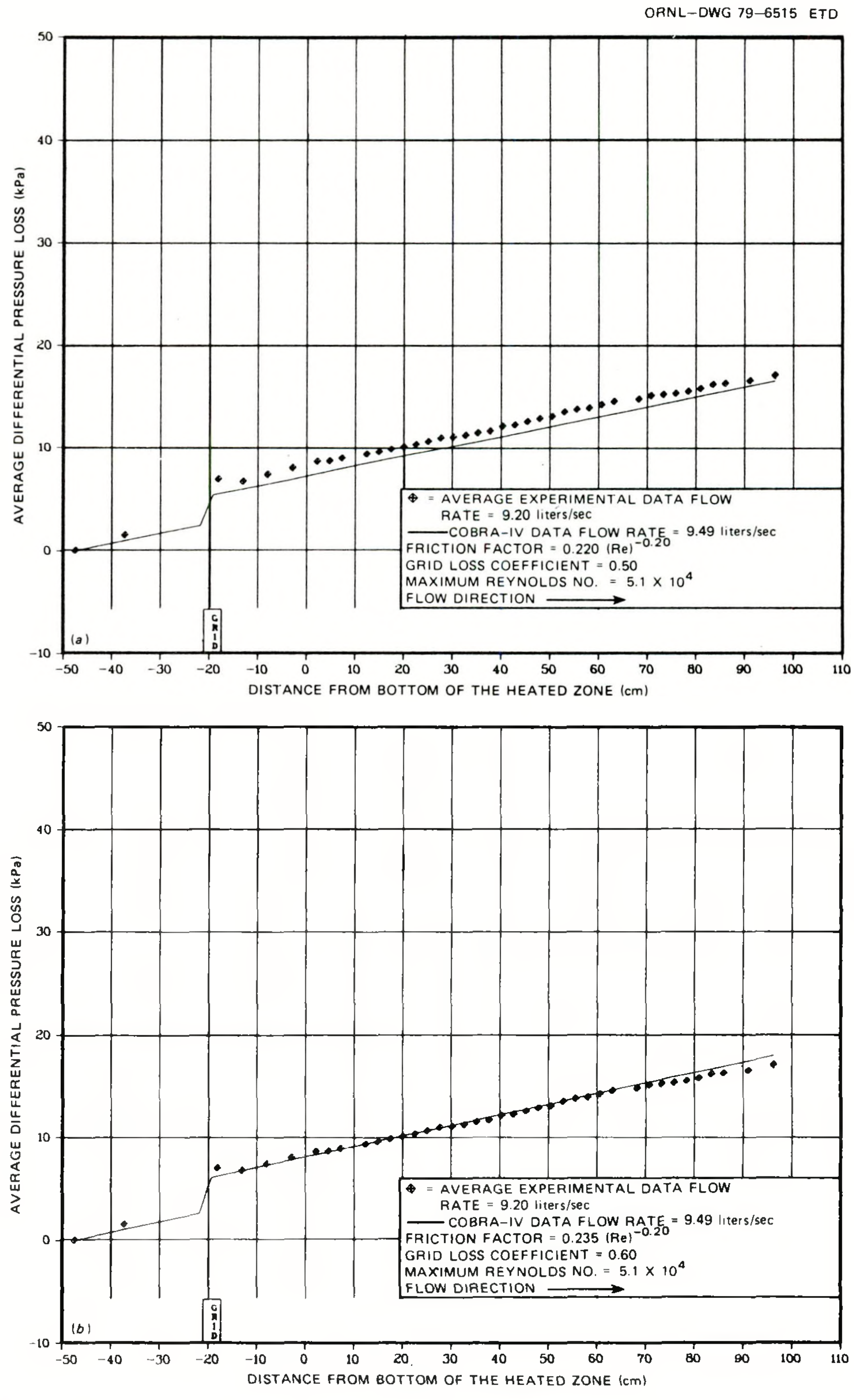



Fig. 5.1. Comparison of the first single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 9.20 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

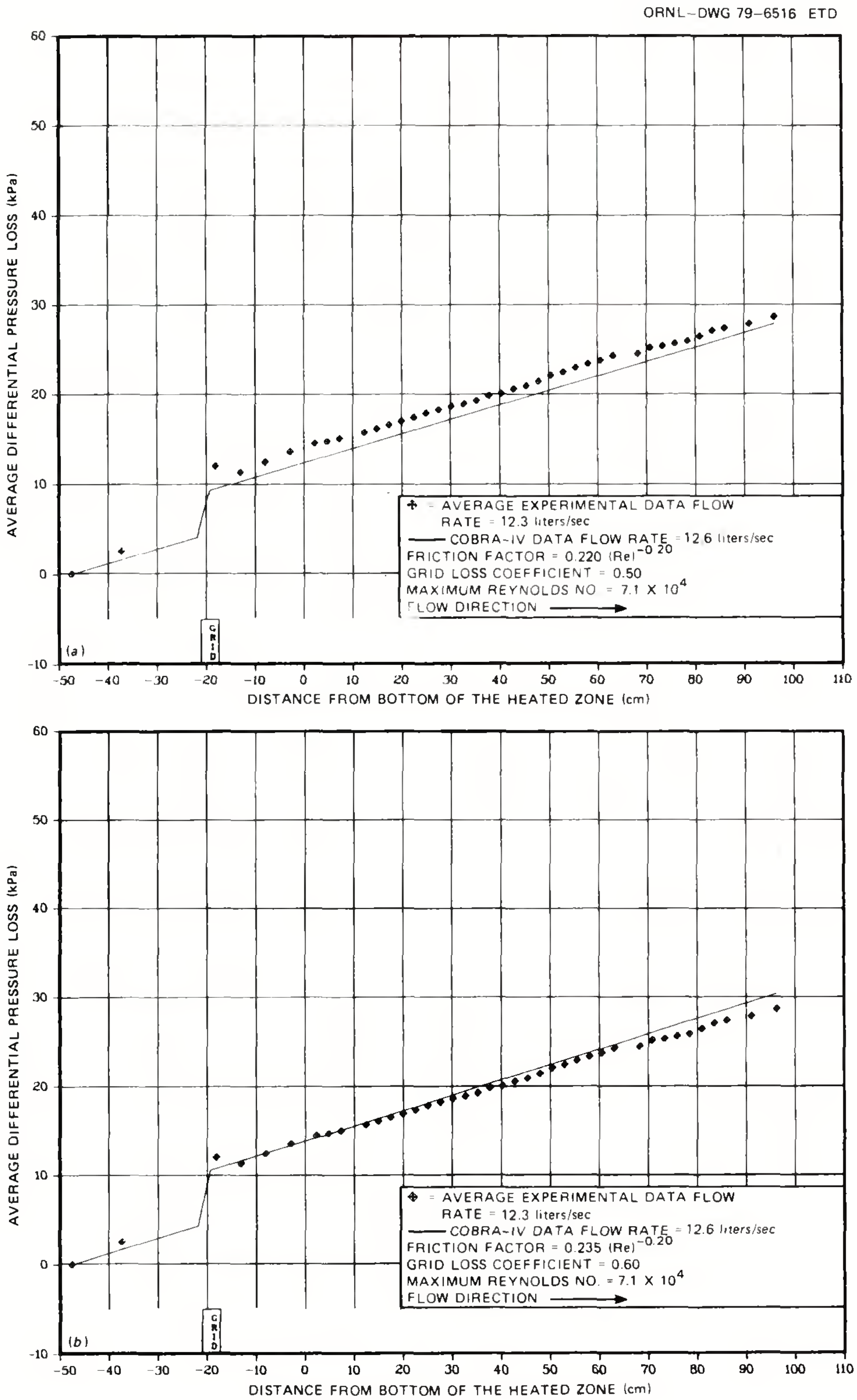



Fig. 5.2. Comparison of the first single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 12.3 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

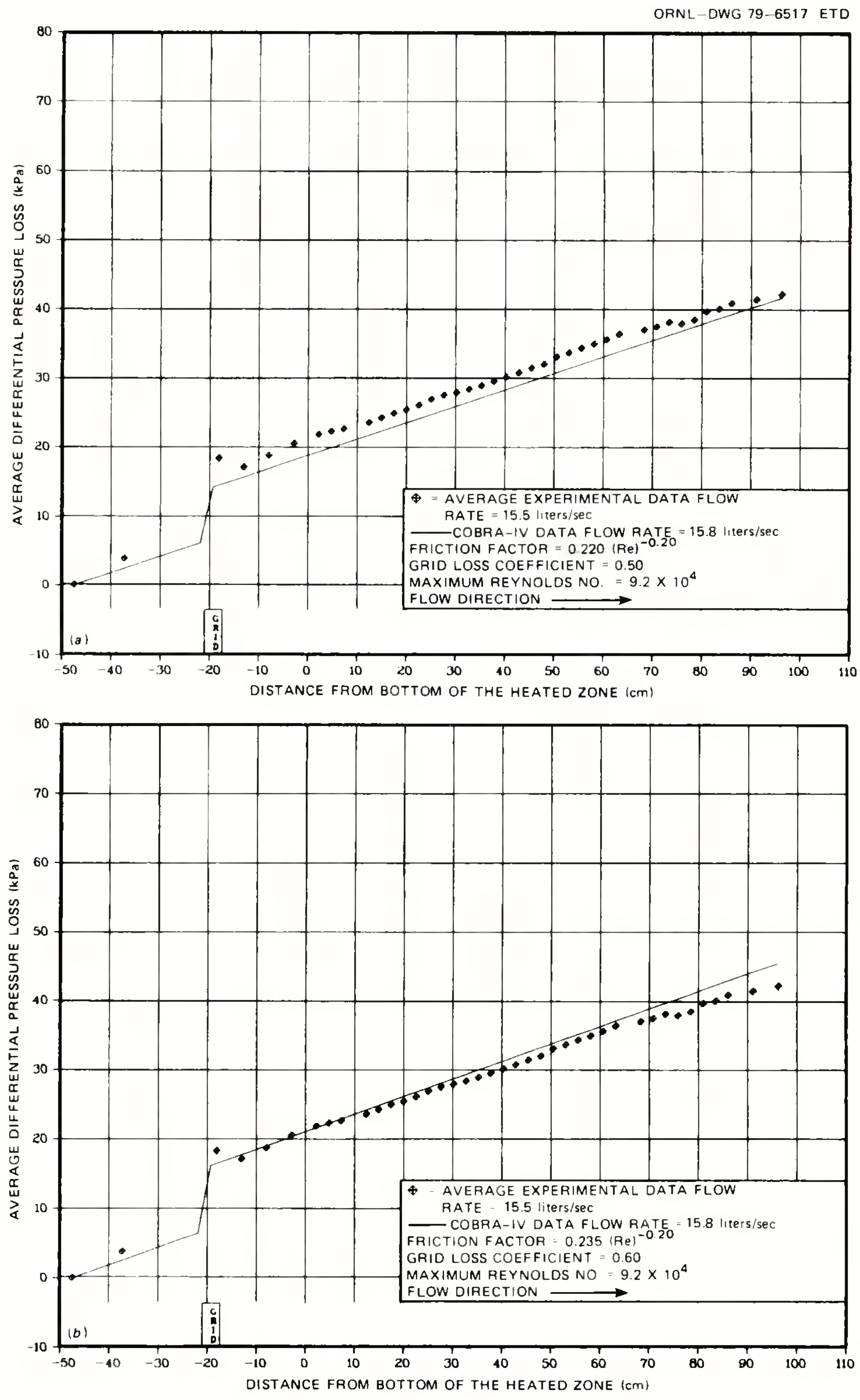



Fig. 5.3. Comparison of the first single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 15.5 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

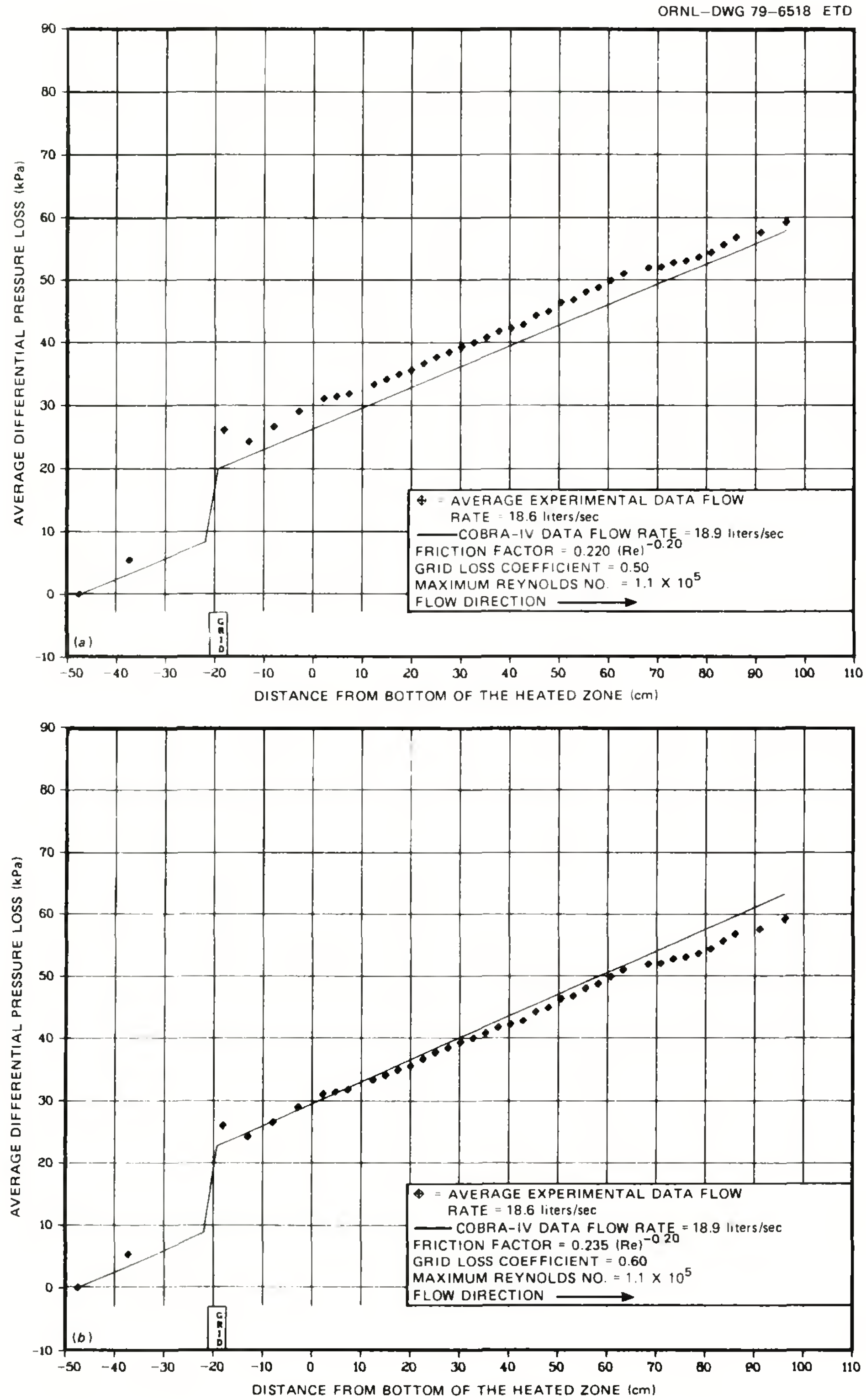



Fig. 5.4. Comparison of the first single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 18.6 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

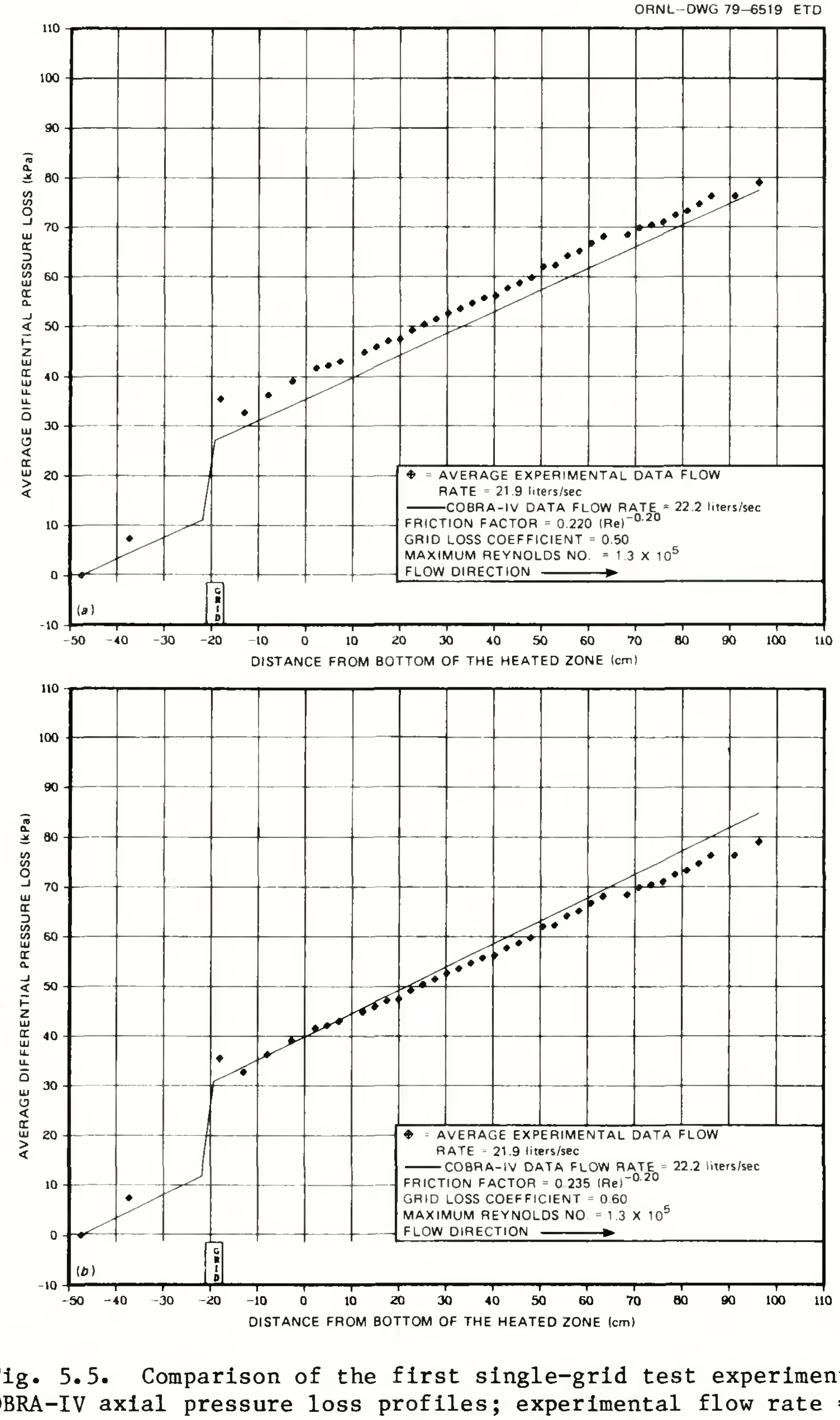



Fig. 5.5. Comparison of the first single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 21.9 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

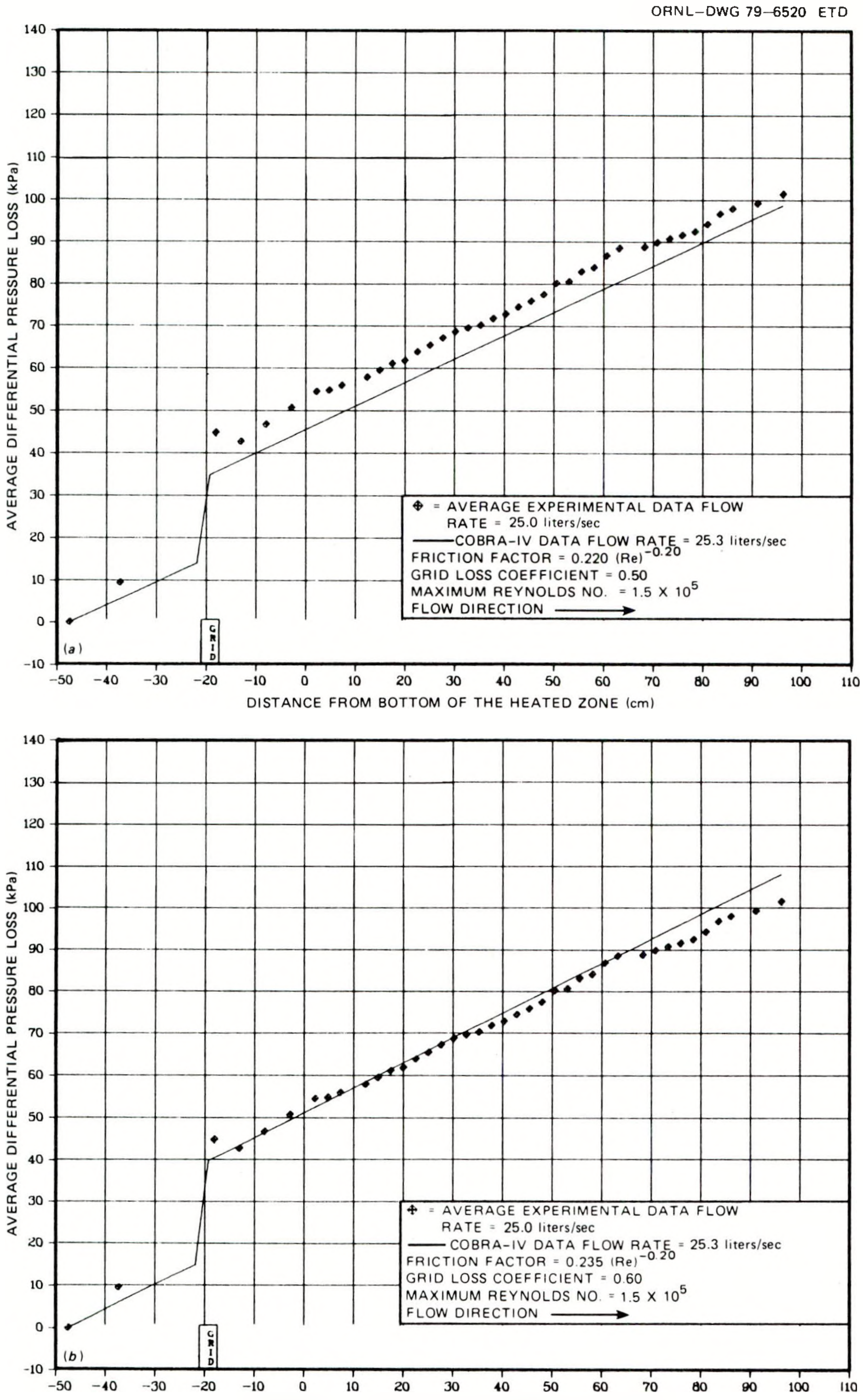



Fig. 5.6. Comparison of the first single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 25.0 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

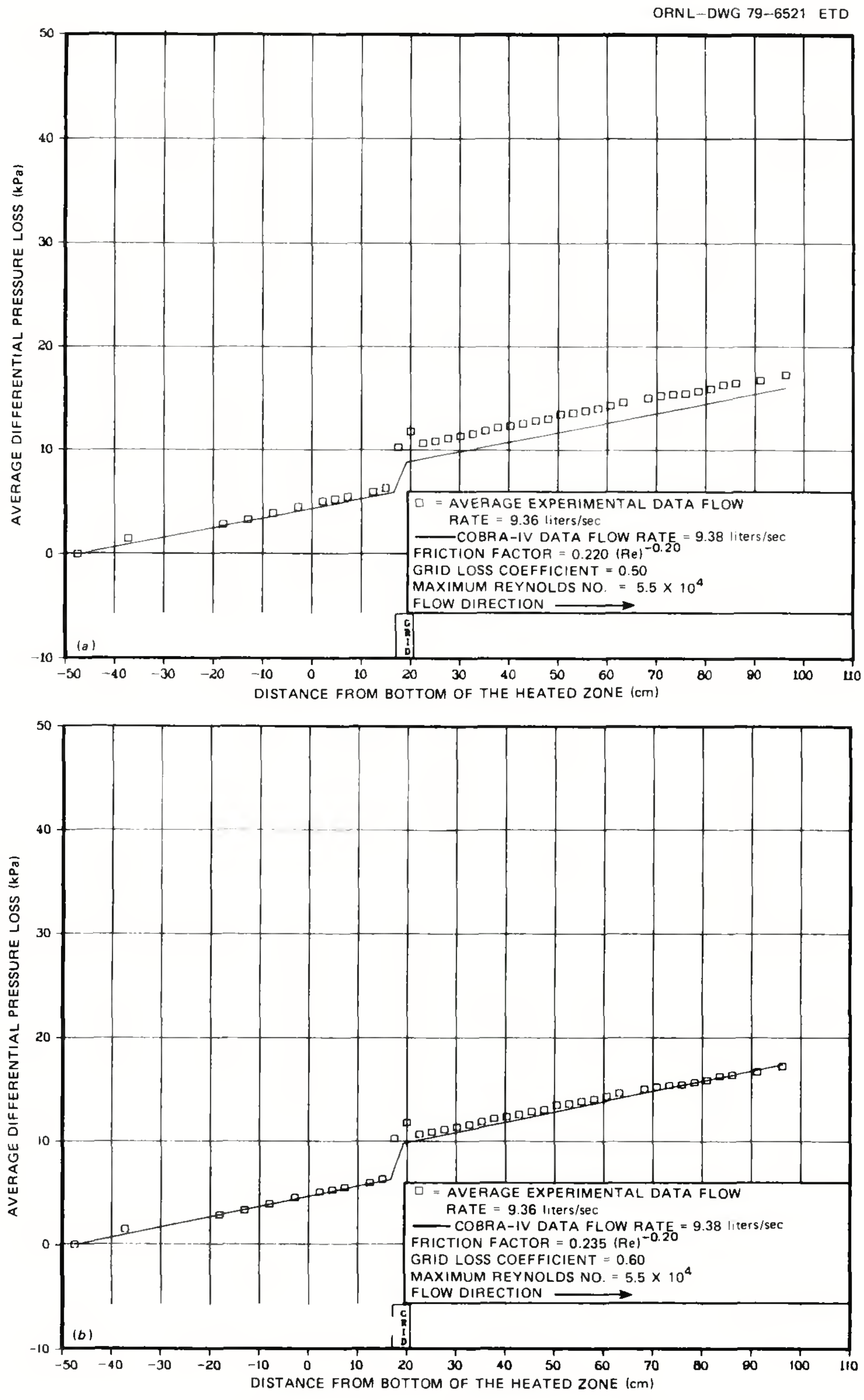



Fig. 5.7. Comparison of the second single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 9.36 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

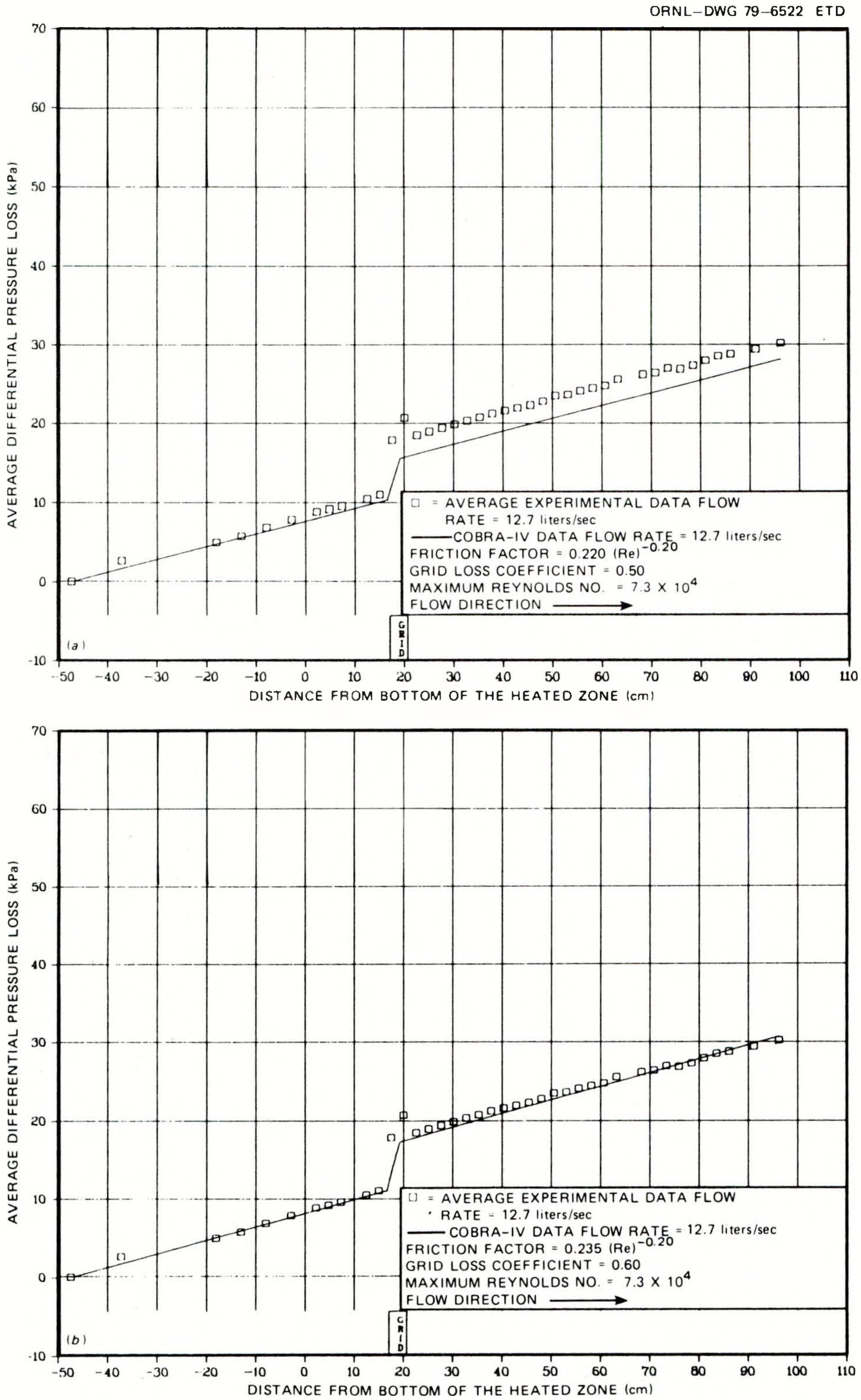



Fig. 5.8. Comparison of the second single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 12.7 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

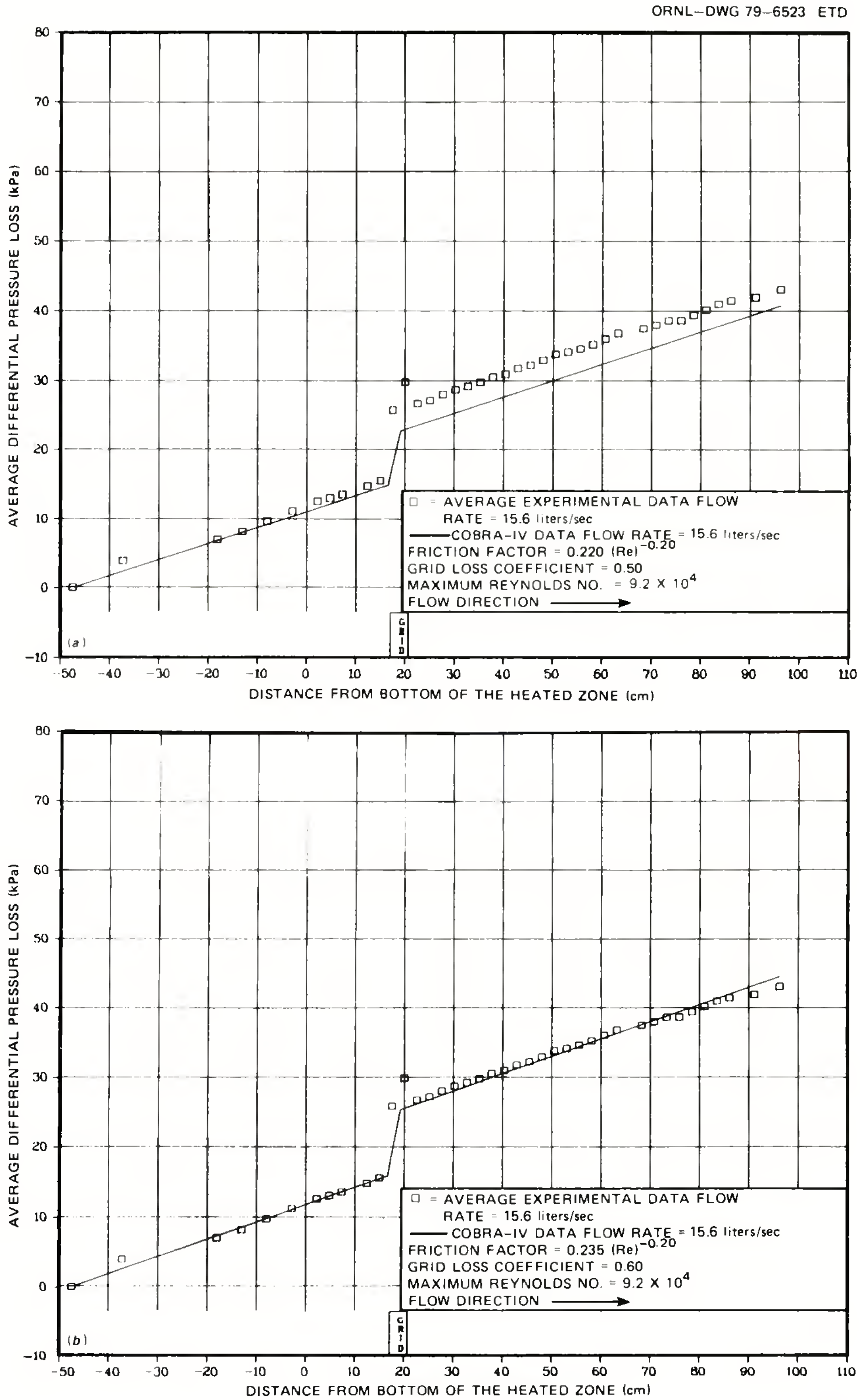



Fig. 5.9. Comparison of the second single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 15.6 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

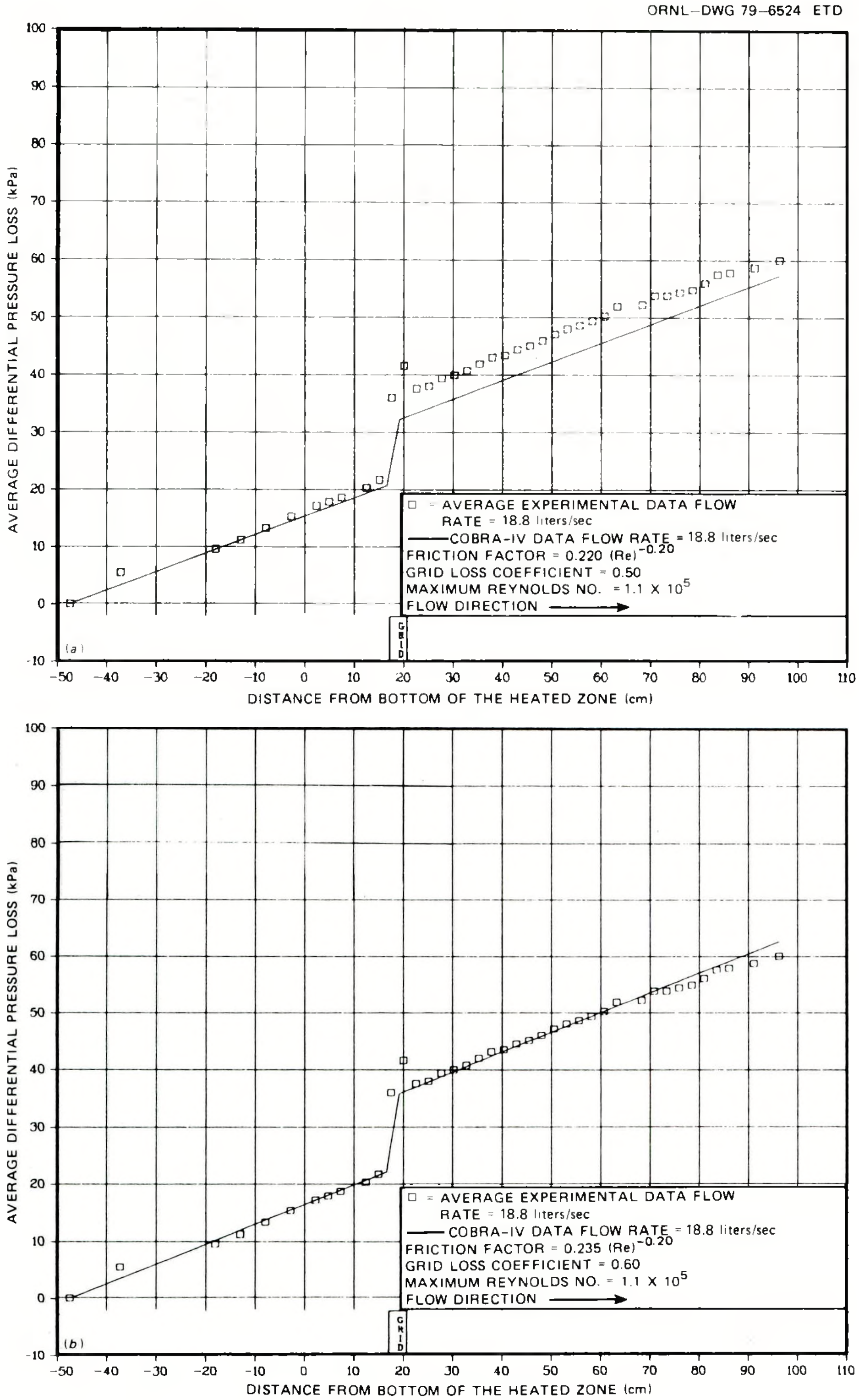



Fig. 5.10. Comparison of the second single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 18.8 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

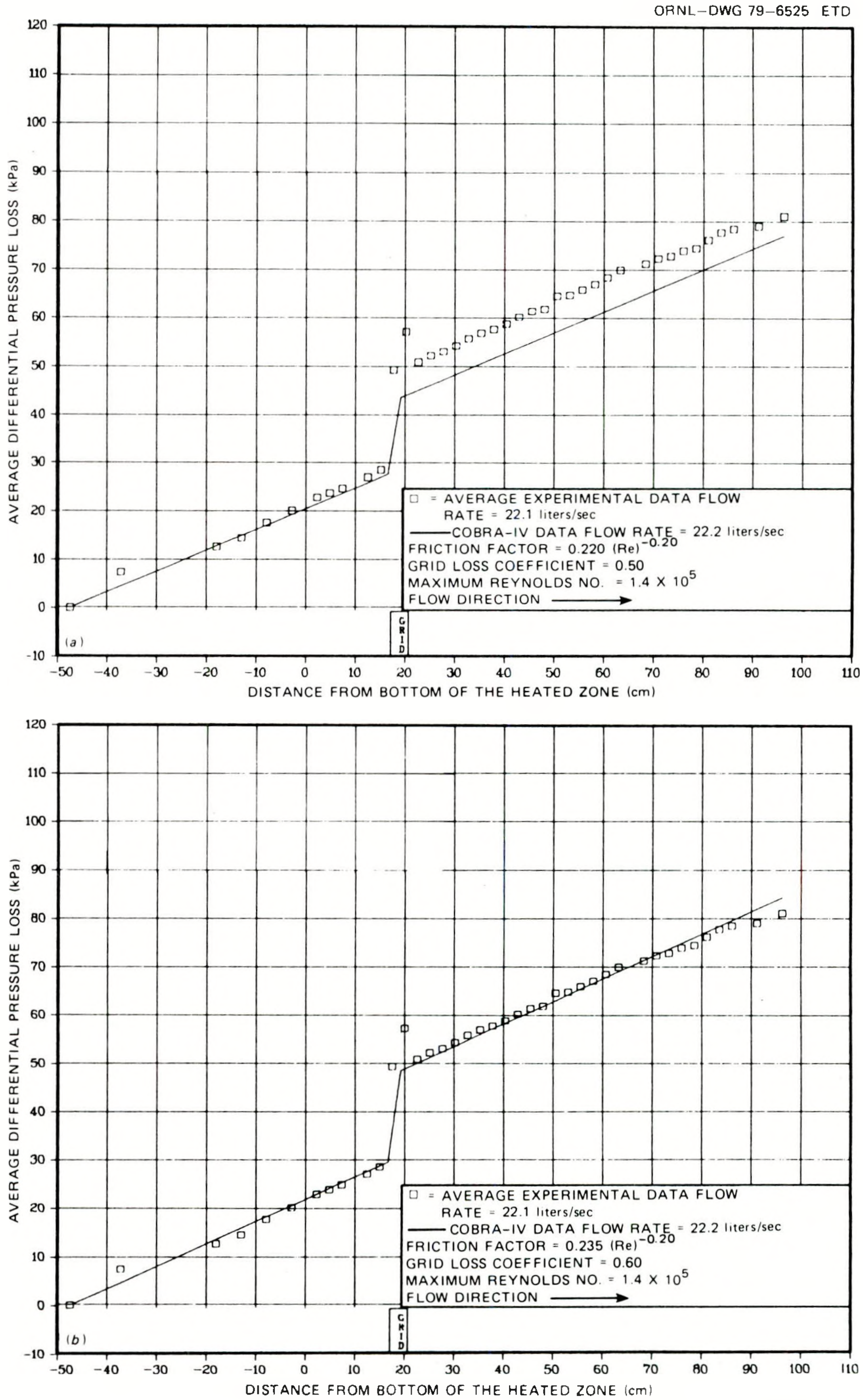



Fig. 5.11. Comparison of the second single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 22.1 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

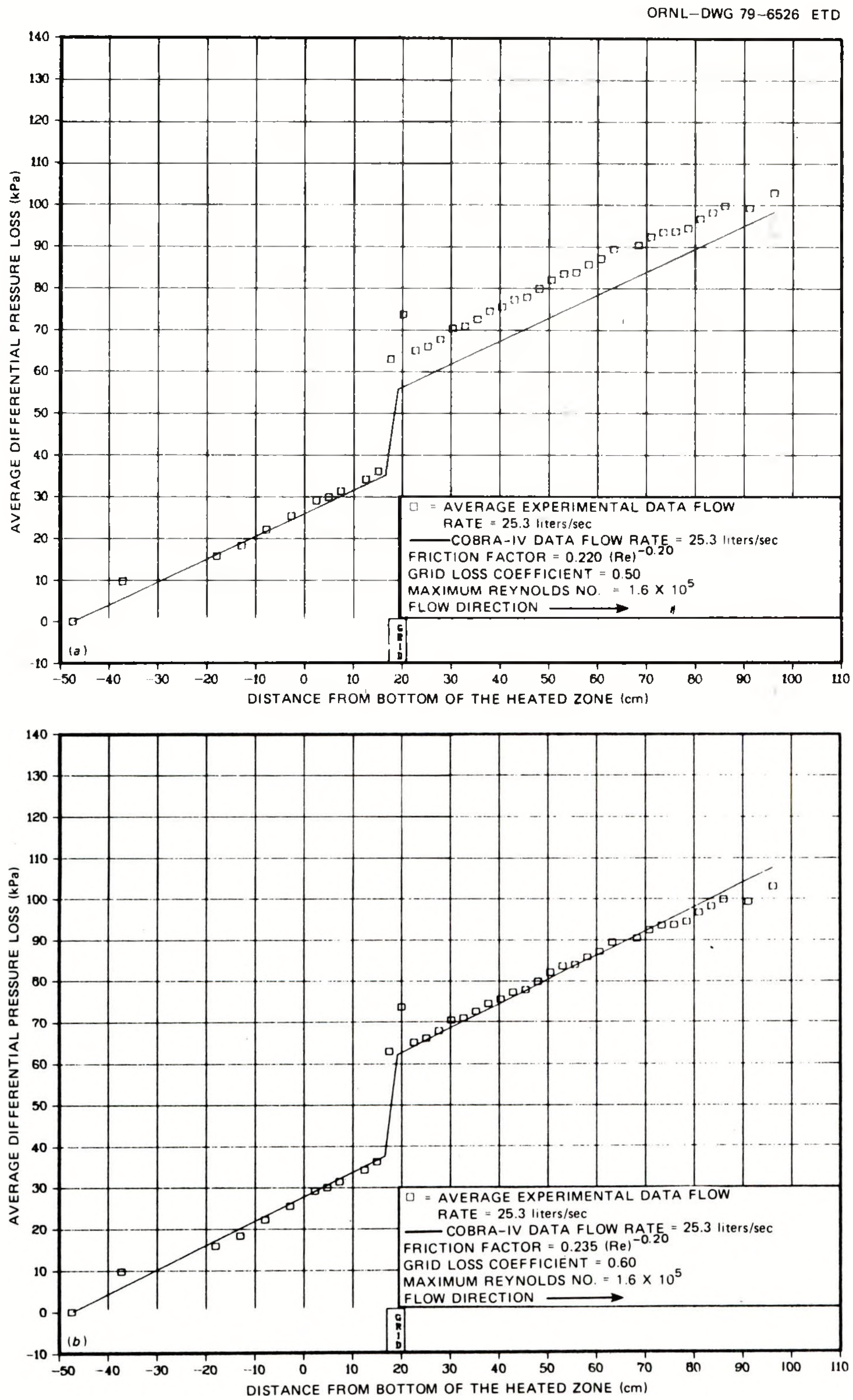



Fig. 5.12. Comparison of the second single-grid test experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 25.3 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

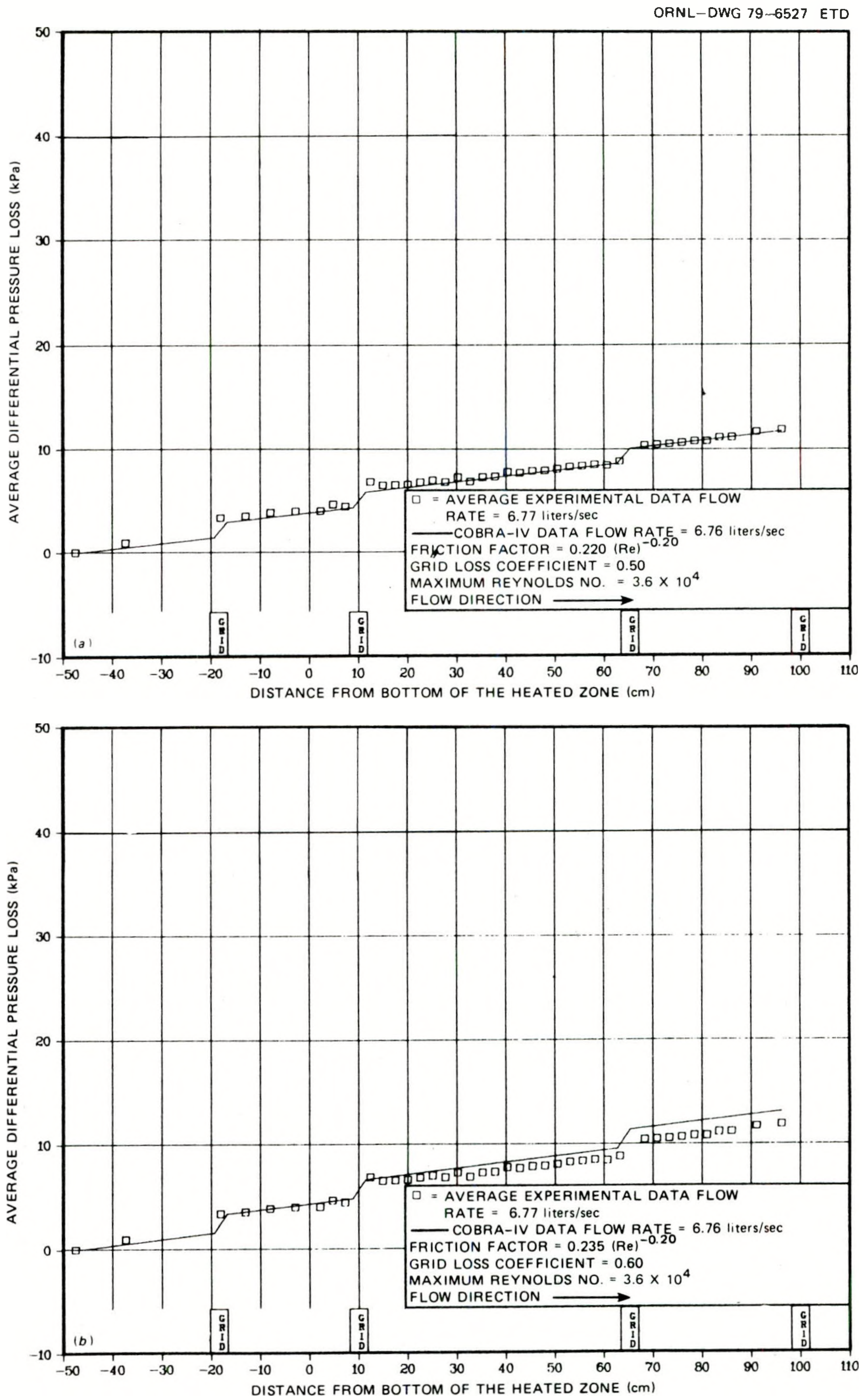



Fig. 5.13. Comparison of reference bundle/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 6.77 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

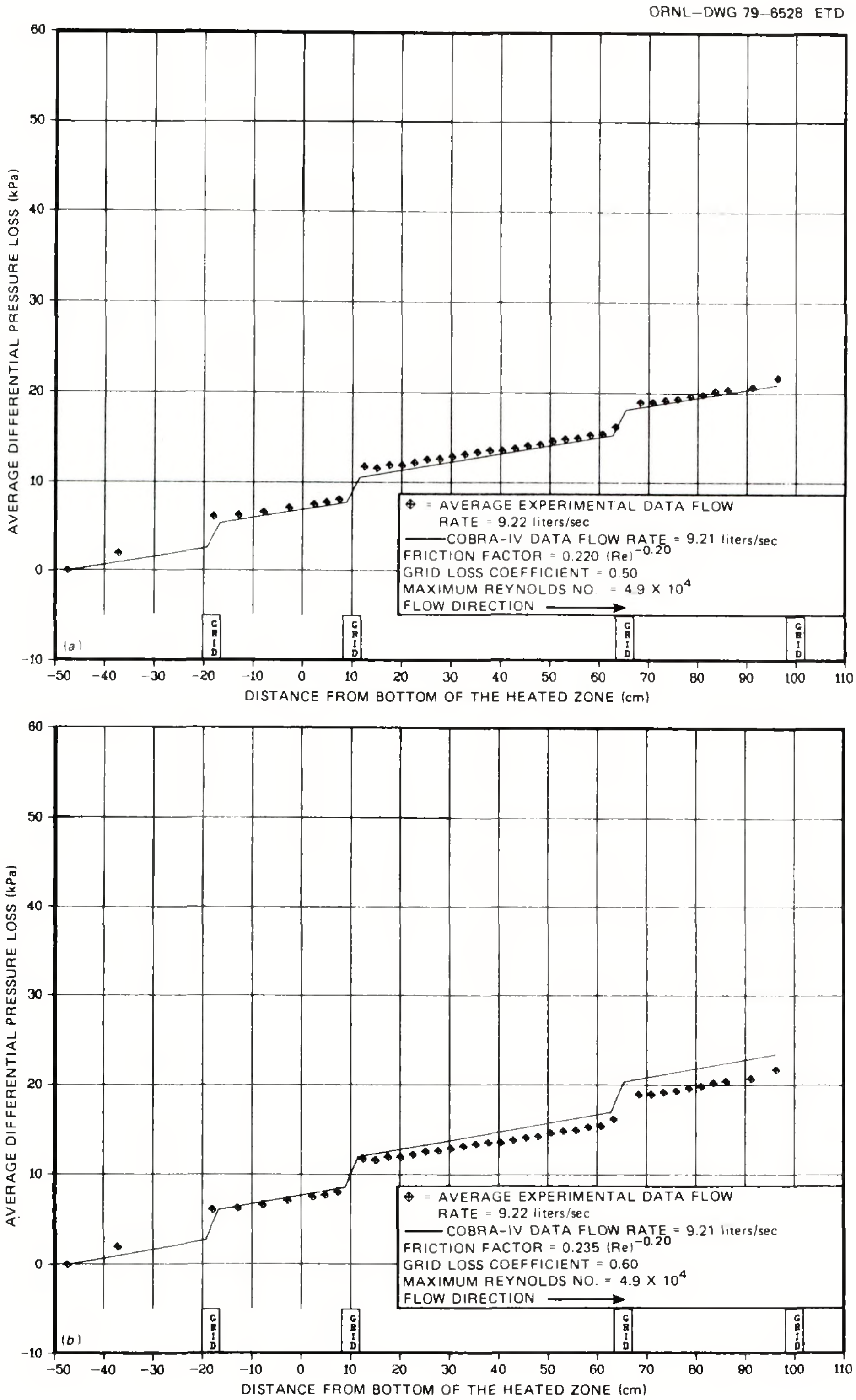



Fig. 5.14. Comparison of reference bundle/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 9.22 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

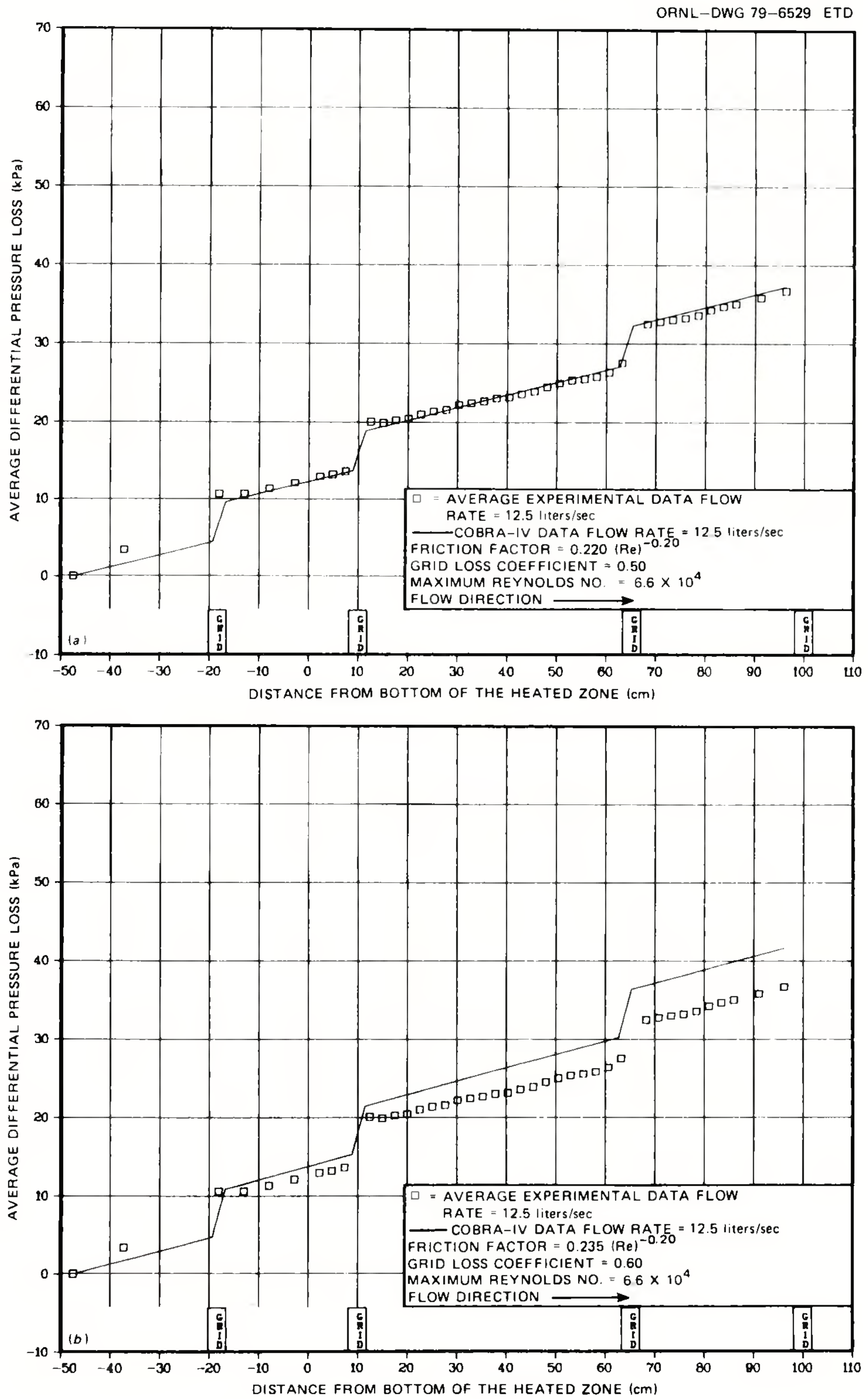



Fig. 5.15. Comparison of reference bundle/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 12.5 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

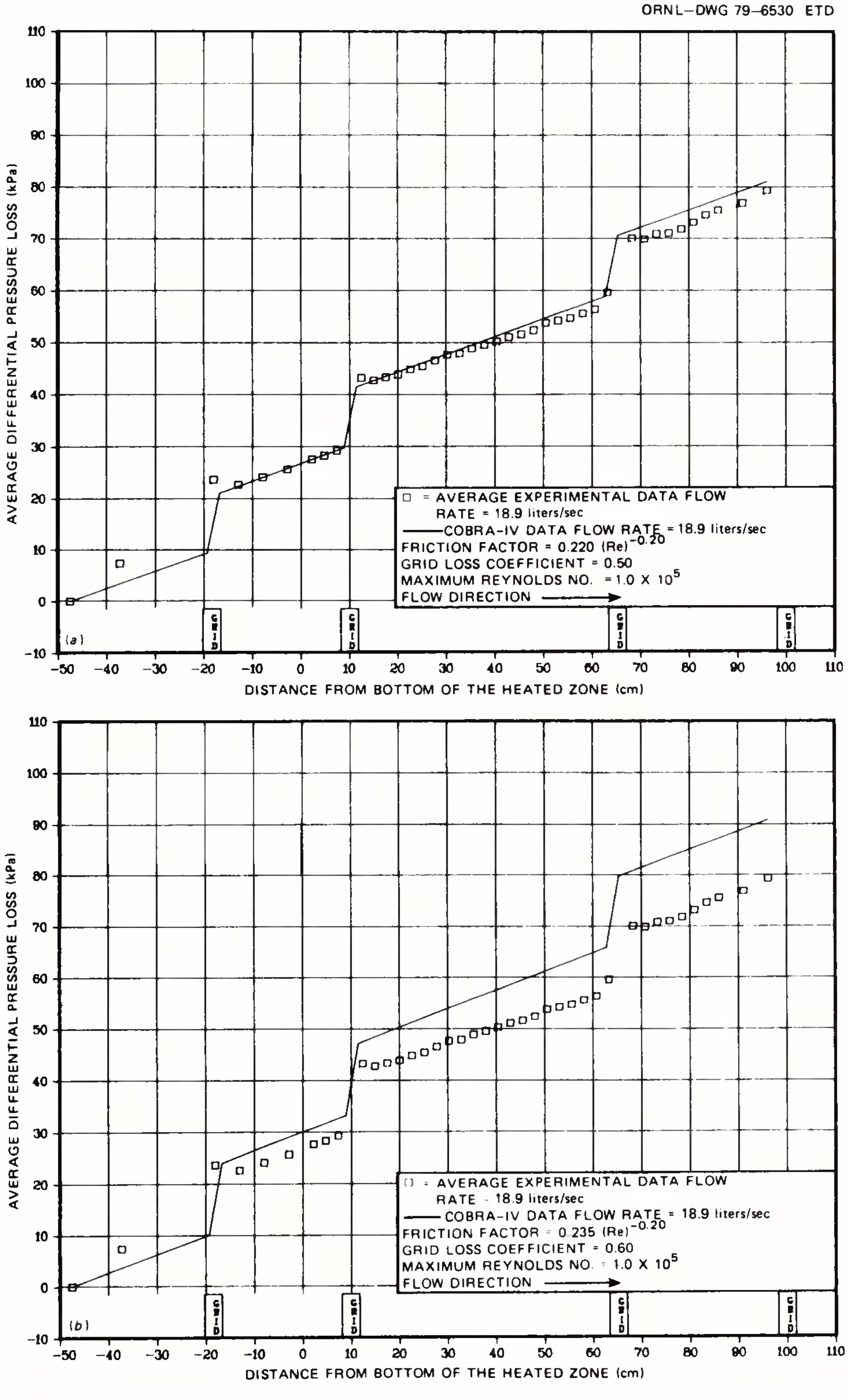



Fig. 5.16. Comparison of reference bundle/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 18.9 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

ORNL-DWG 79-6531 ETD

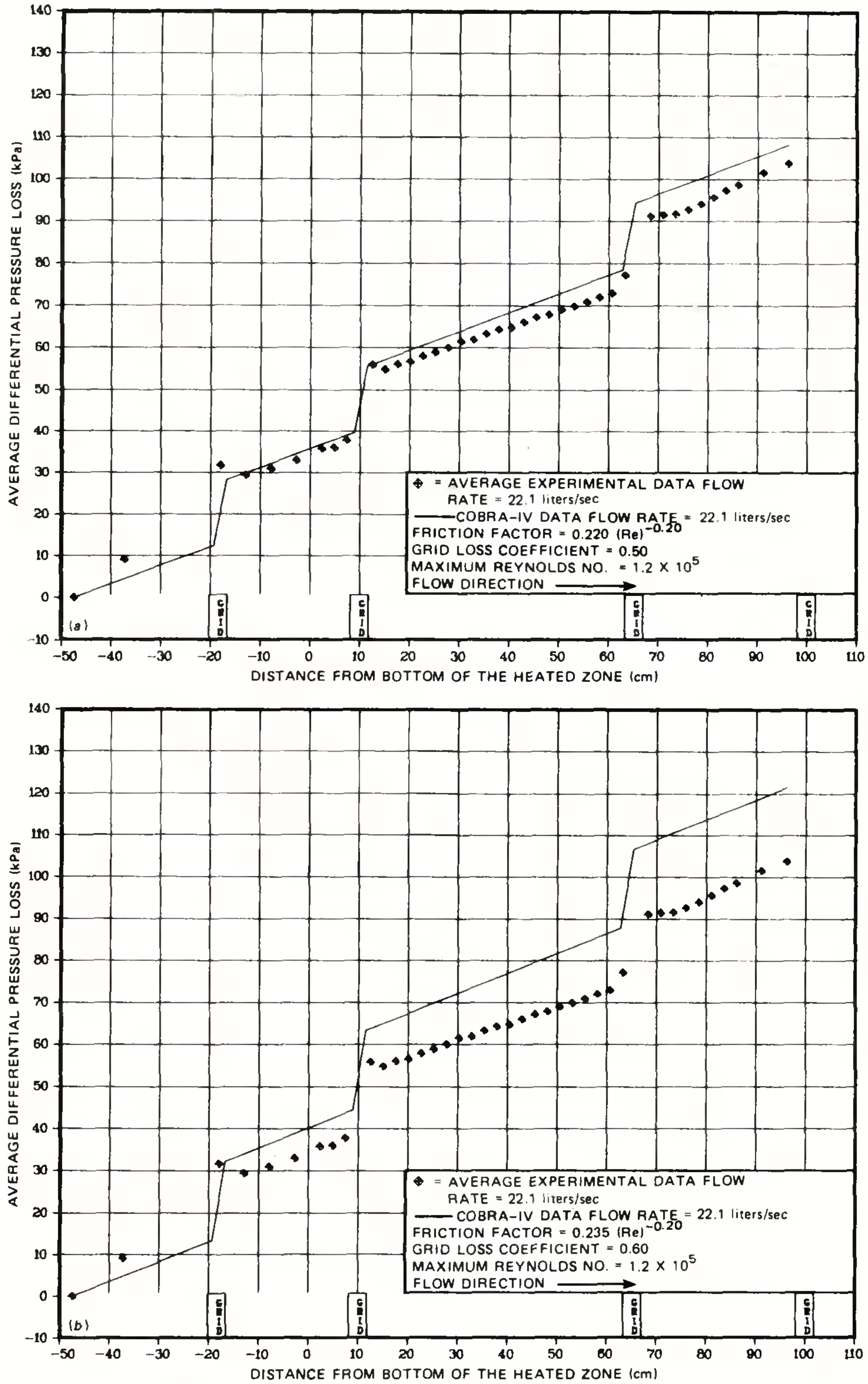



Fig. 5.17. Comparison of reference bundle/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 22.1 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

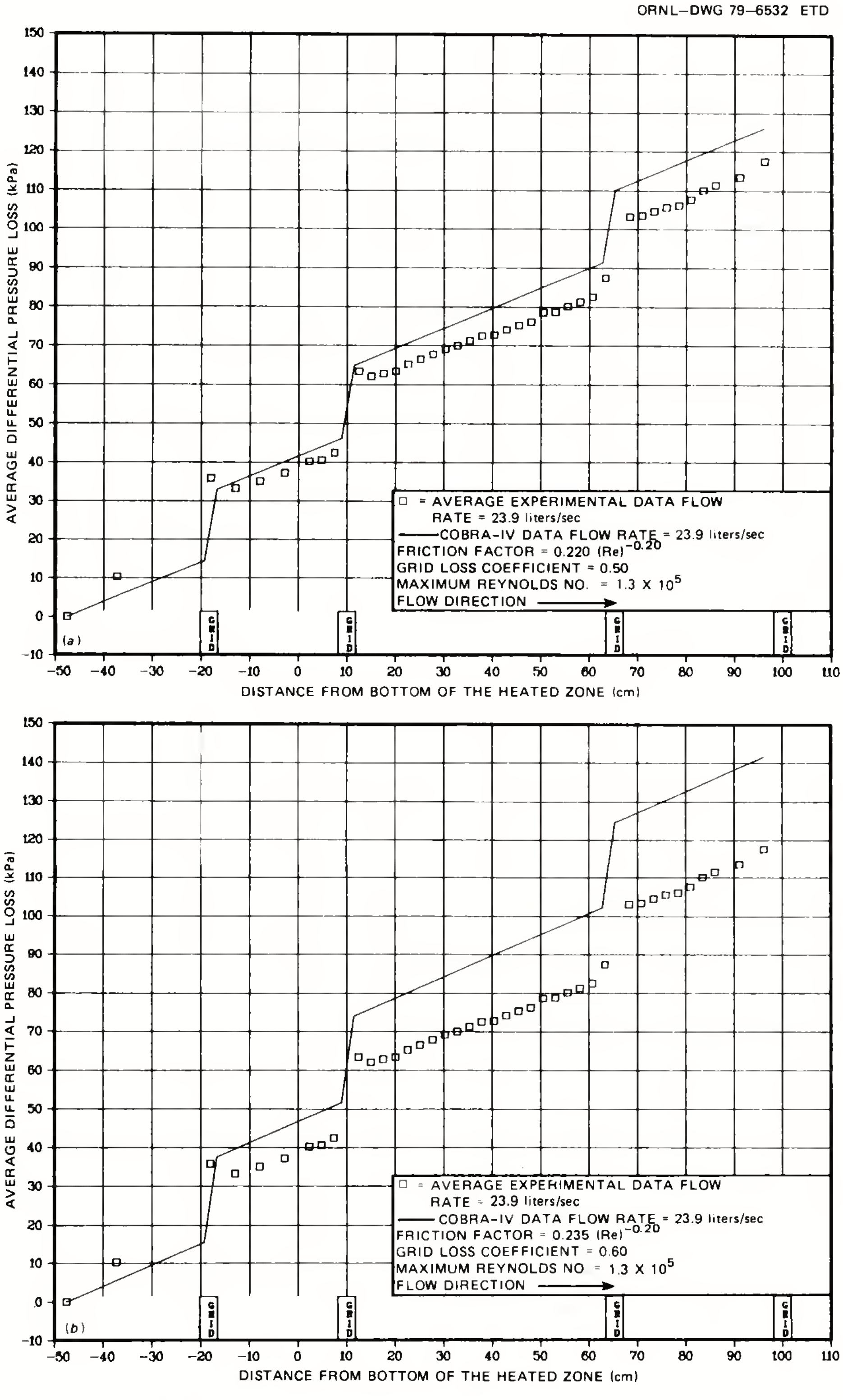



Fig. 5.18. Comparison of reference bundle/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 23.9 liters/sec. (a) Lower-limit; (b) upper-limit correlation values.

ORNL–DWG 79–6533 ETD

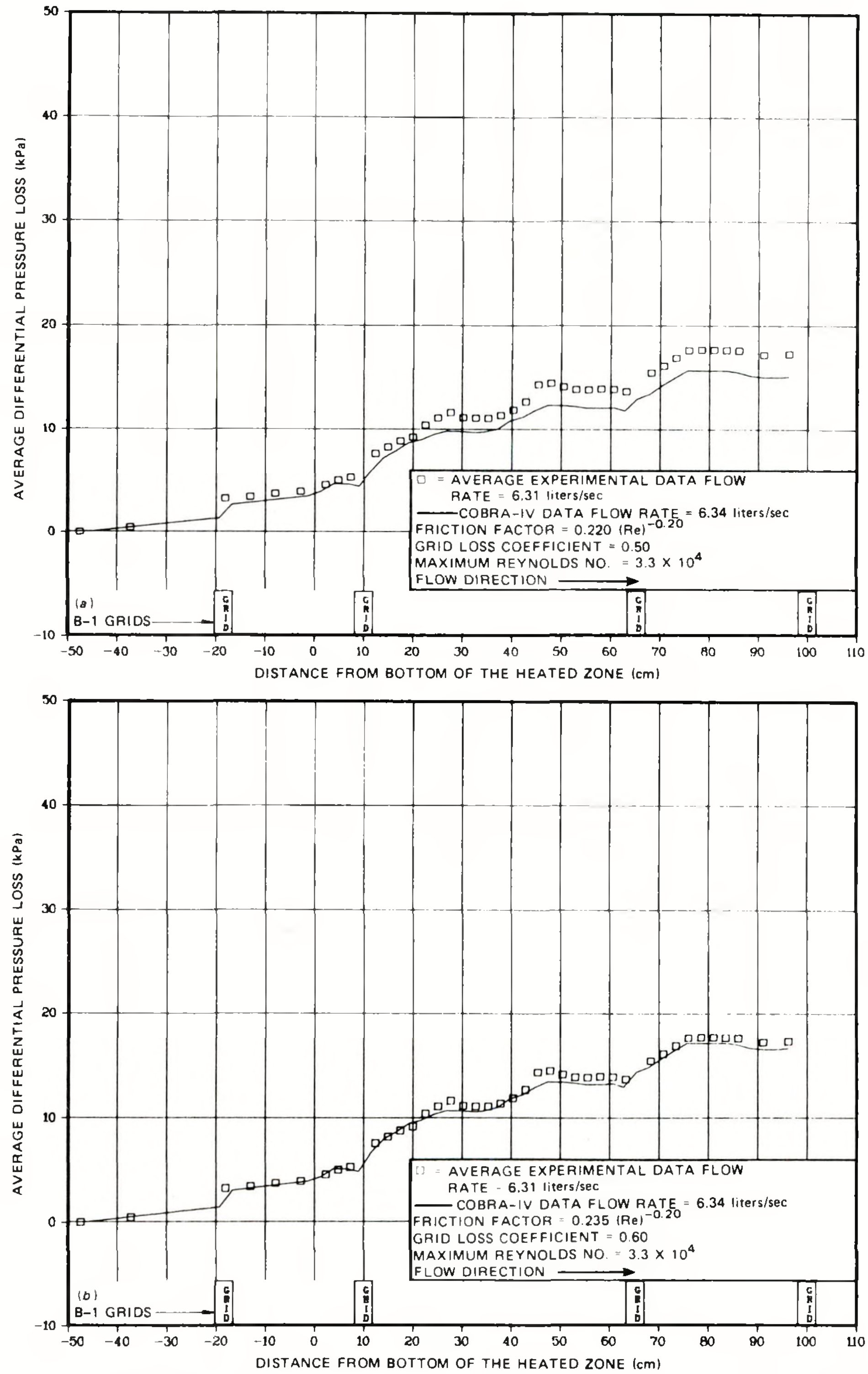



Fig. 5.19. Comparison of B-1/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 6.31 liters/sec; minimum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

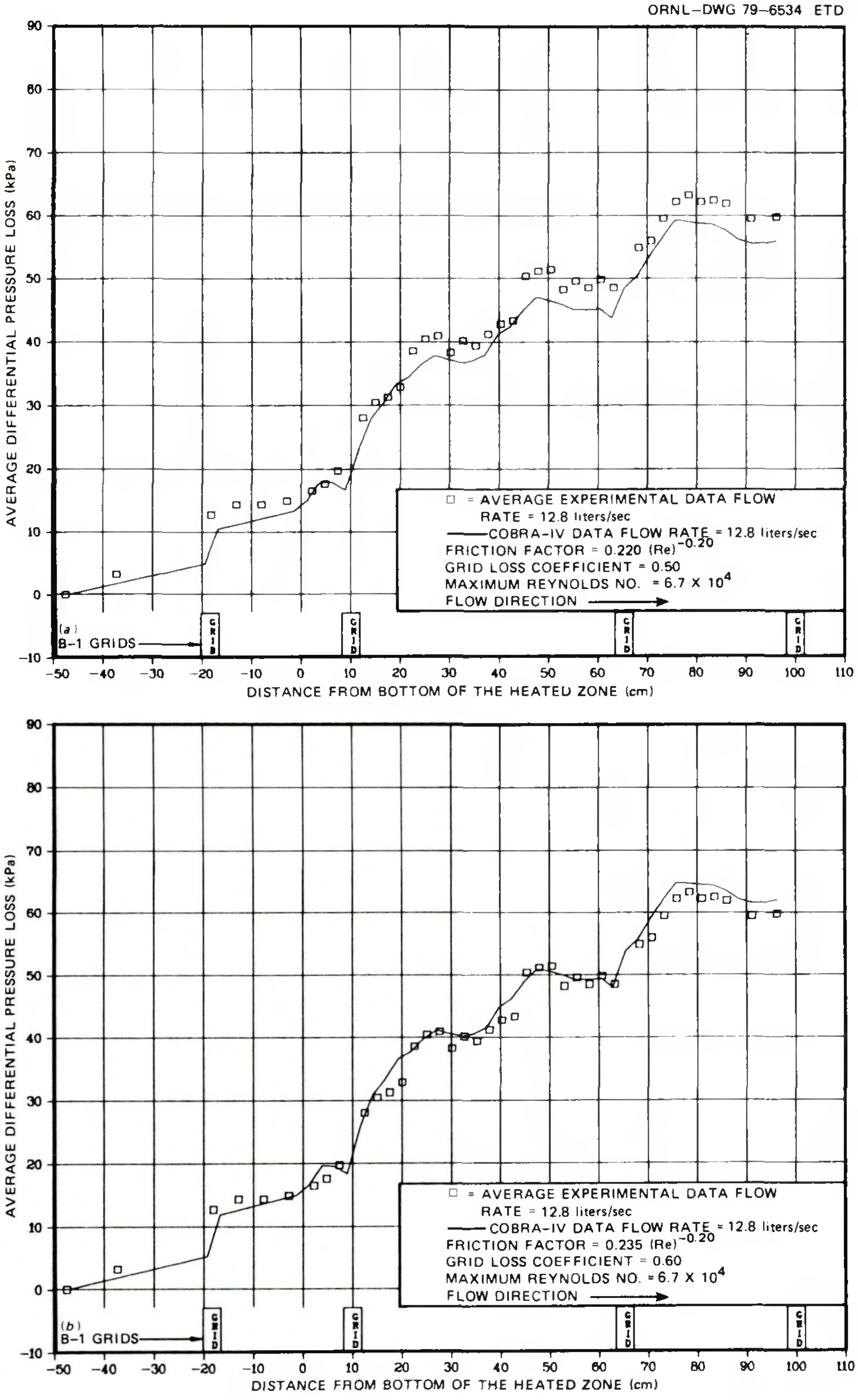
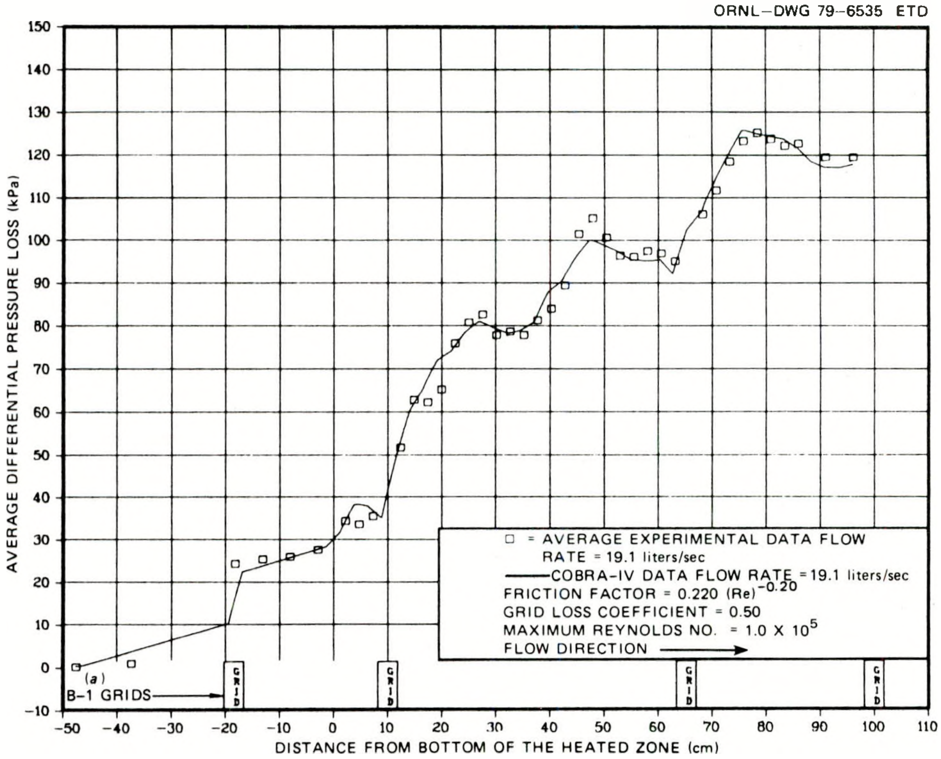



Fig. 5.20. Comparison of B-1/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 12.8 liters/sec; minimum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

ORNL-DWG 79-6535 ETD



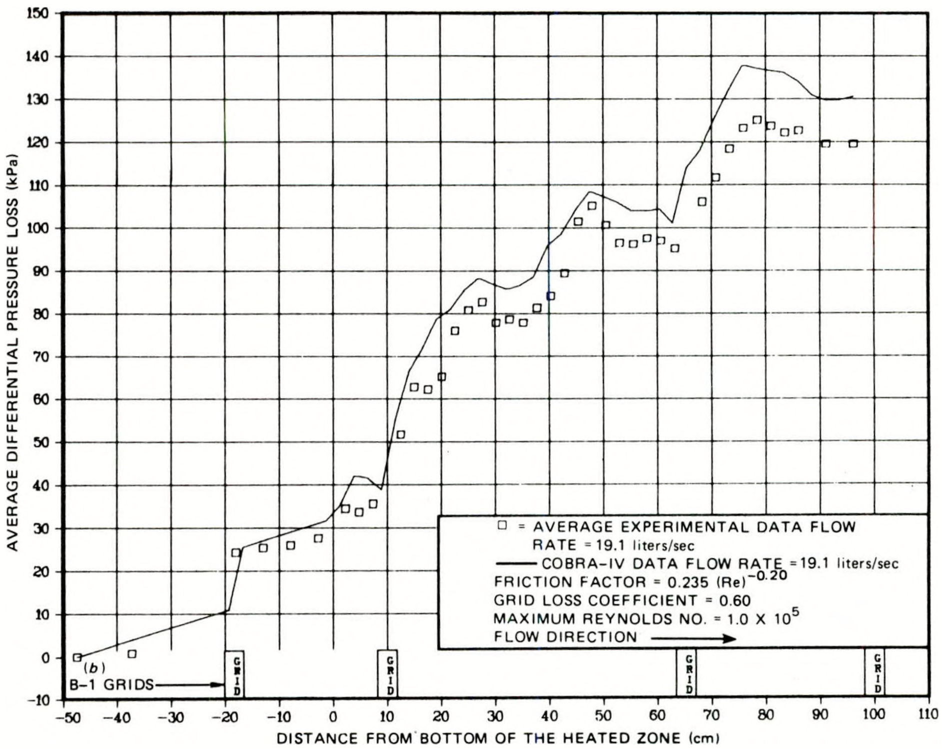
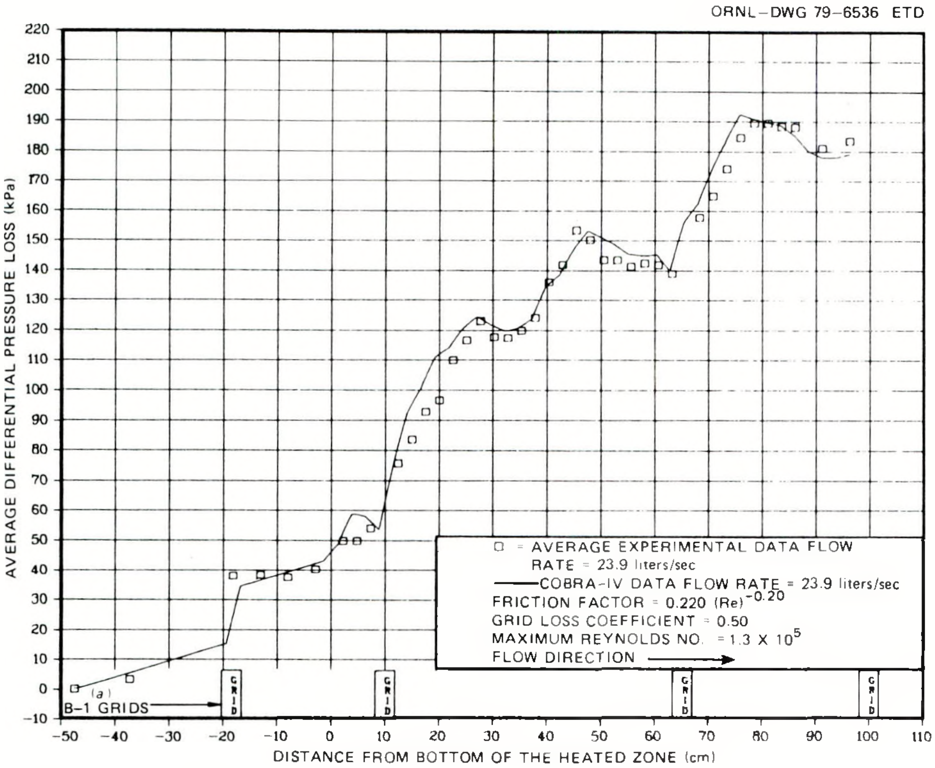




Fig. 5.21. Comparison of B-1/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 19.1 liters/sec; minimum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.



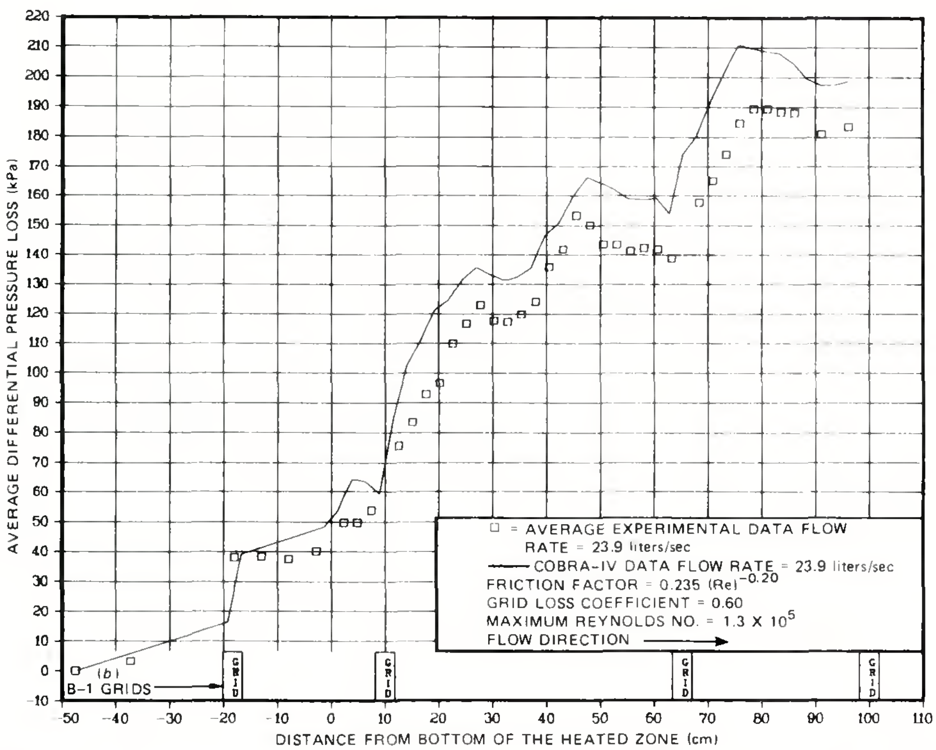




Fig. 5.22. Comparison of B-1/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 23.9 liters/sec; minimum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

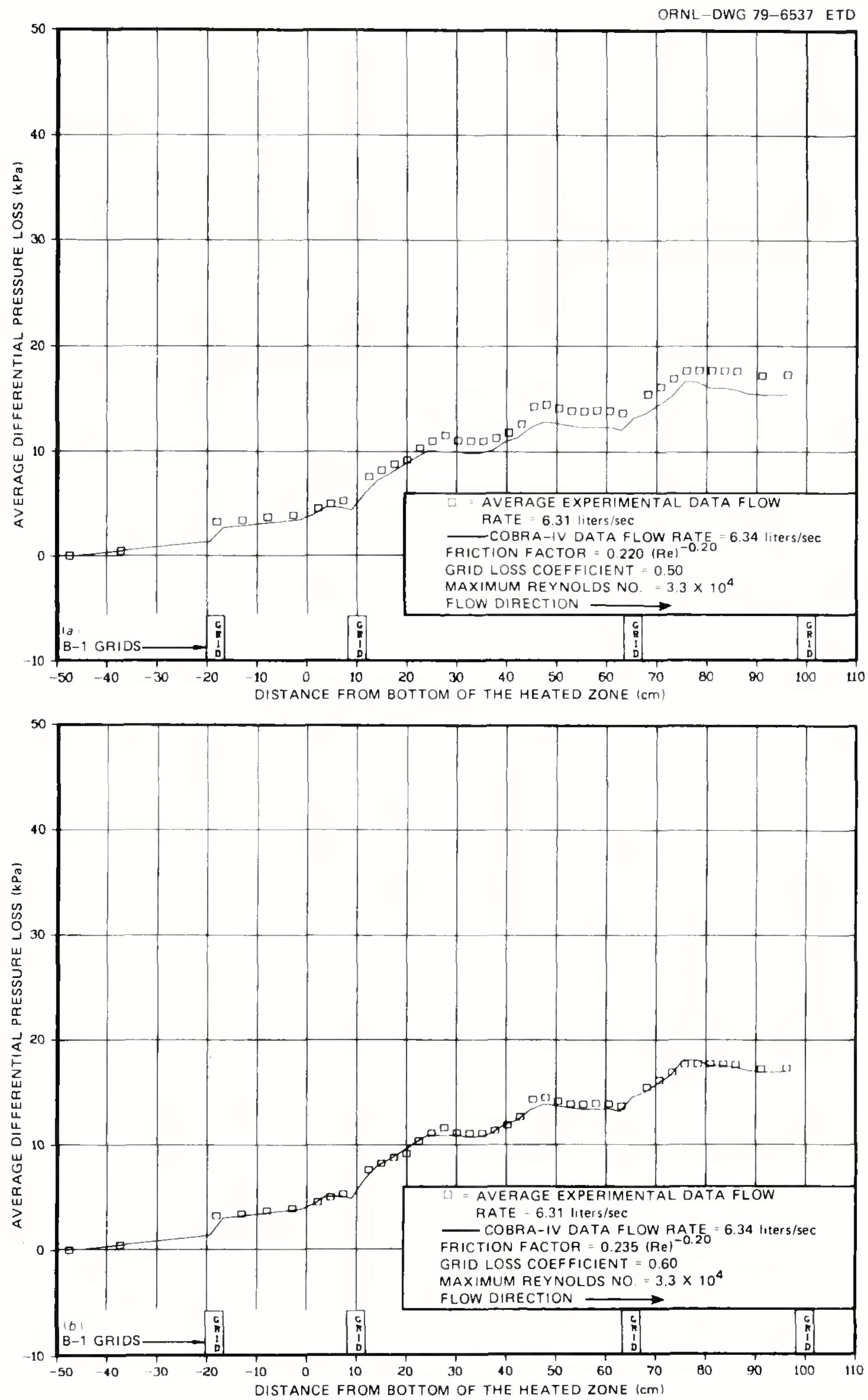



Fig. 5.23. Comparison of B-1/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 6.31 liters/sec; maximum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

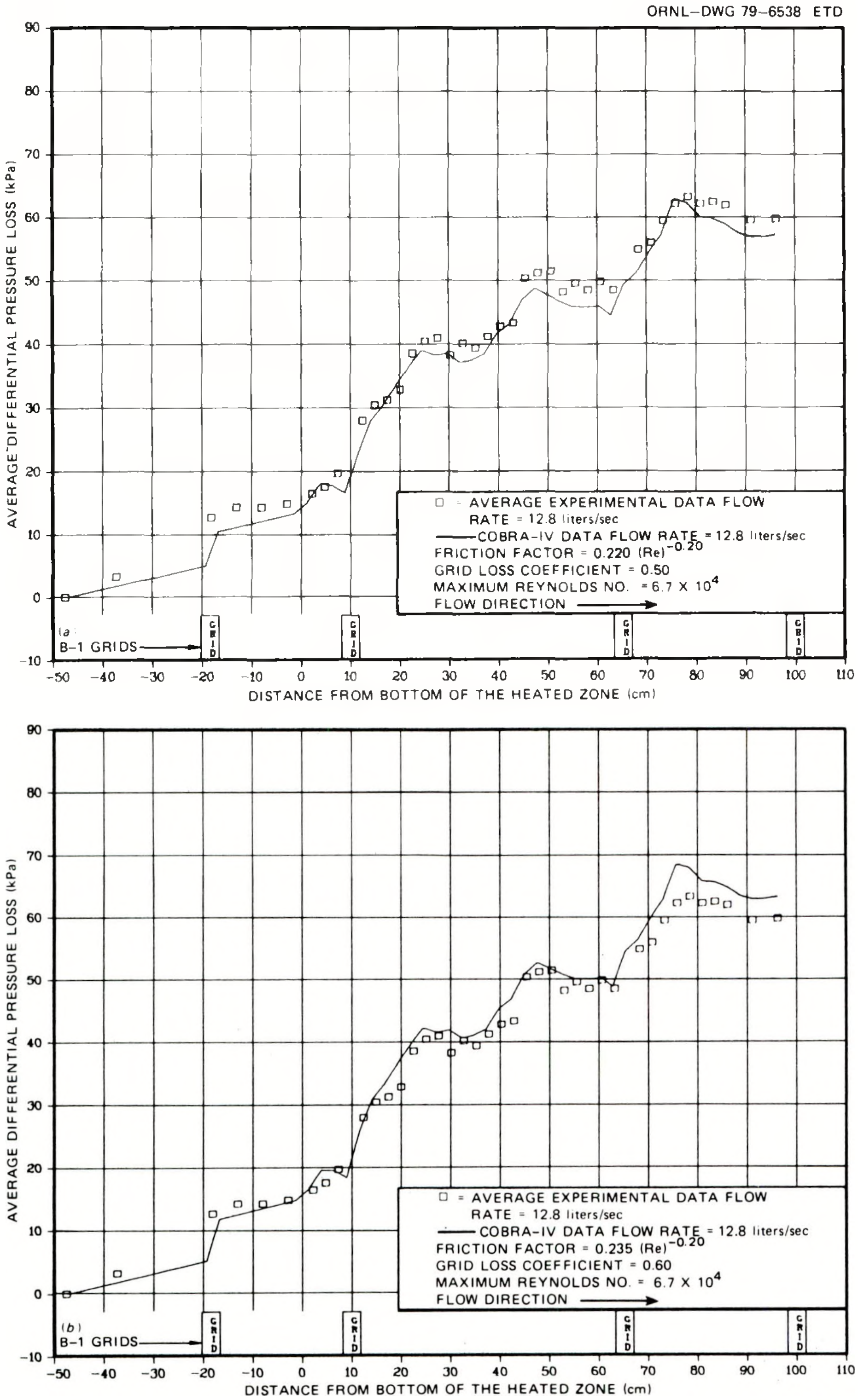



Fig. 5.24. Comparison of B-1/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 12.8 liters/sec; maximum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

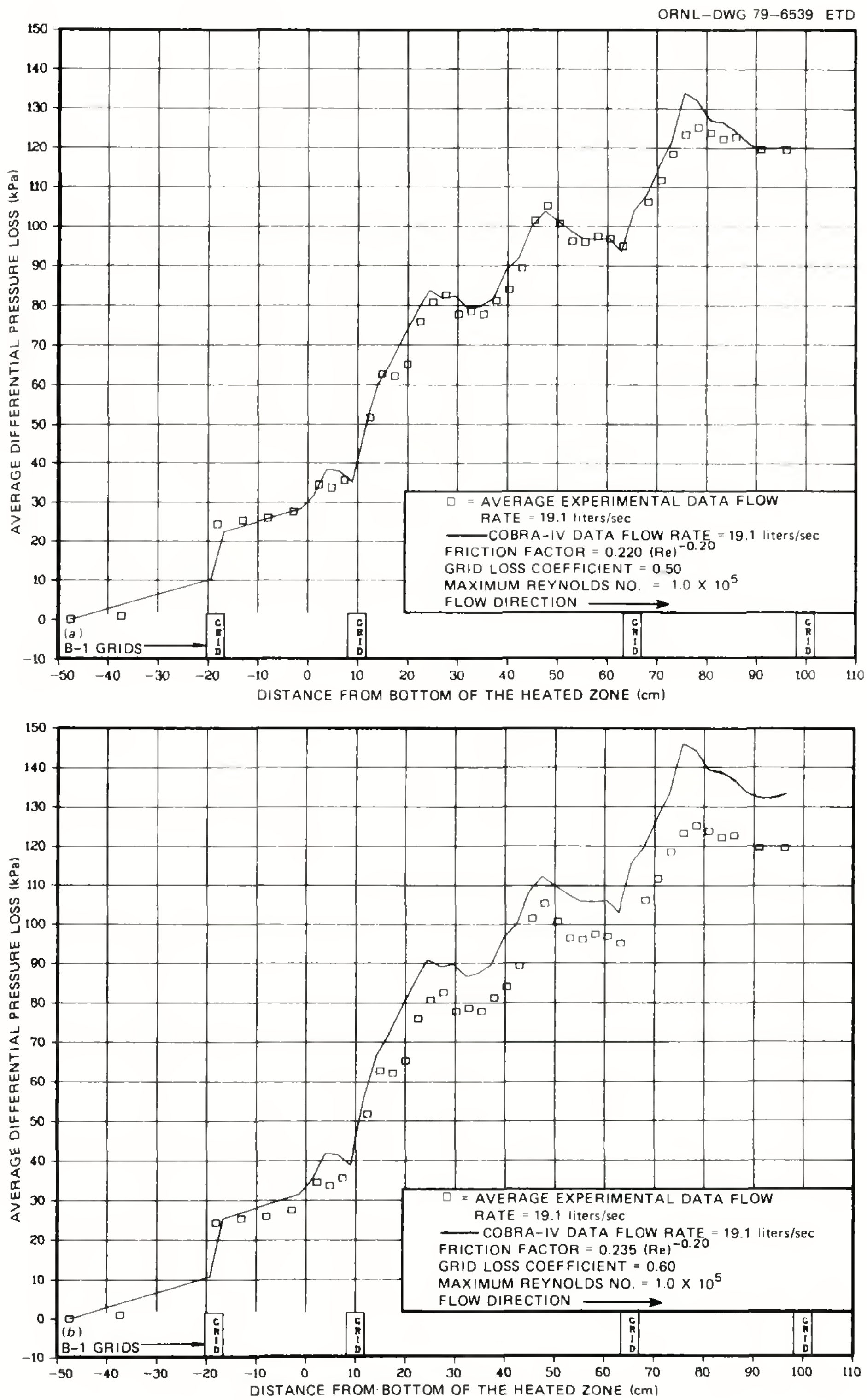



Fig. 5.25. Comparison of B-1/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 19.1 liters/sec; maximum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

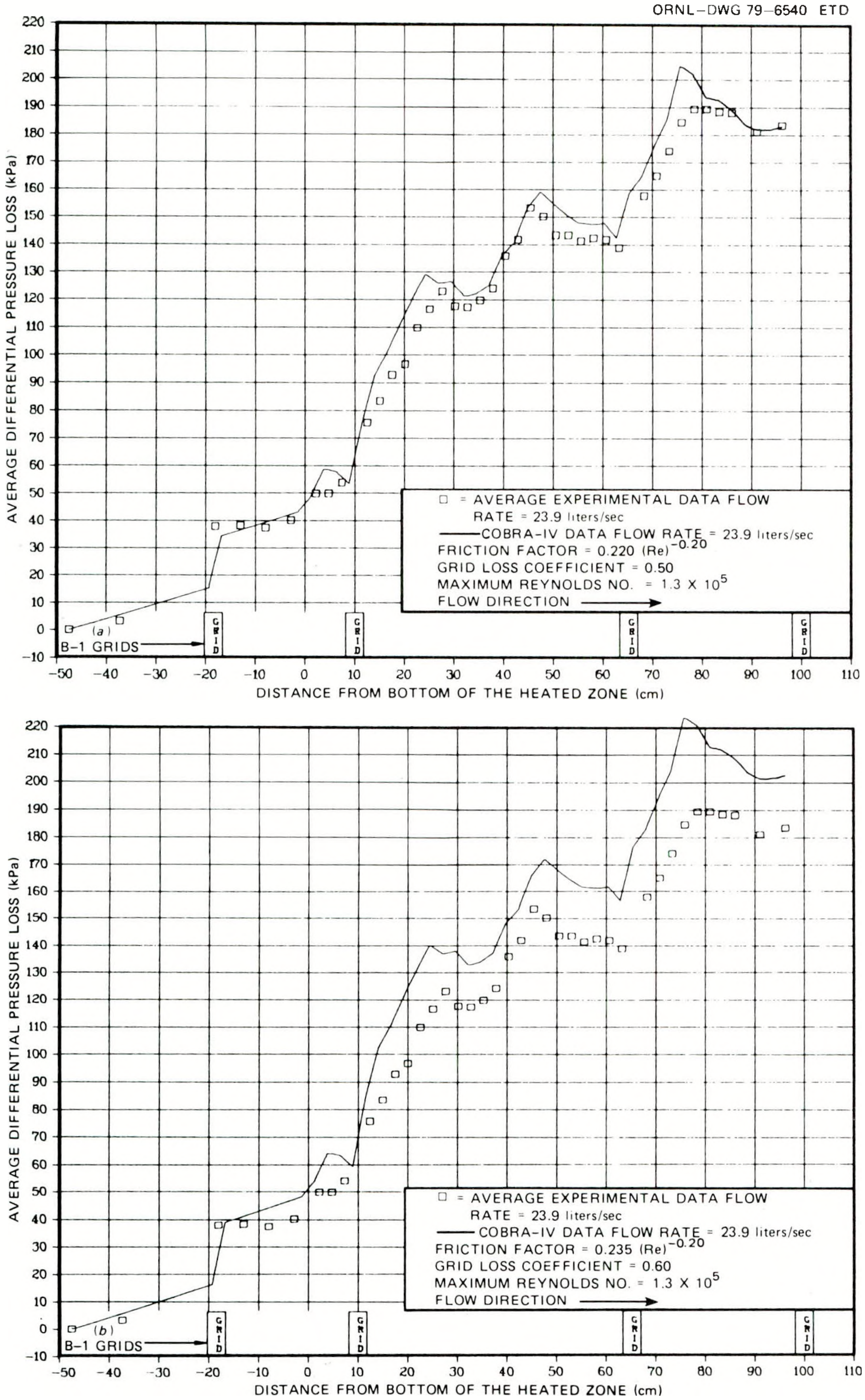



Fig. 5.26. Comparison of B-1/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 23.9 liters/sec; maximum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

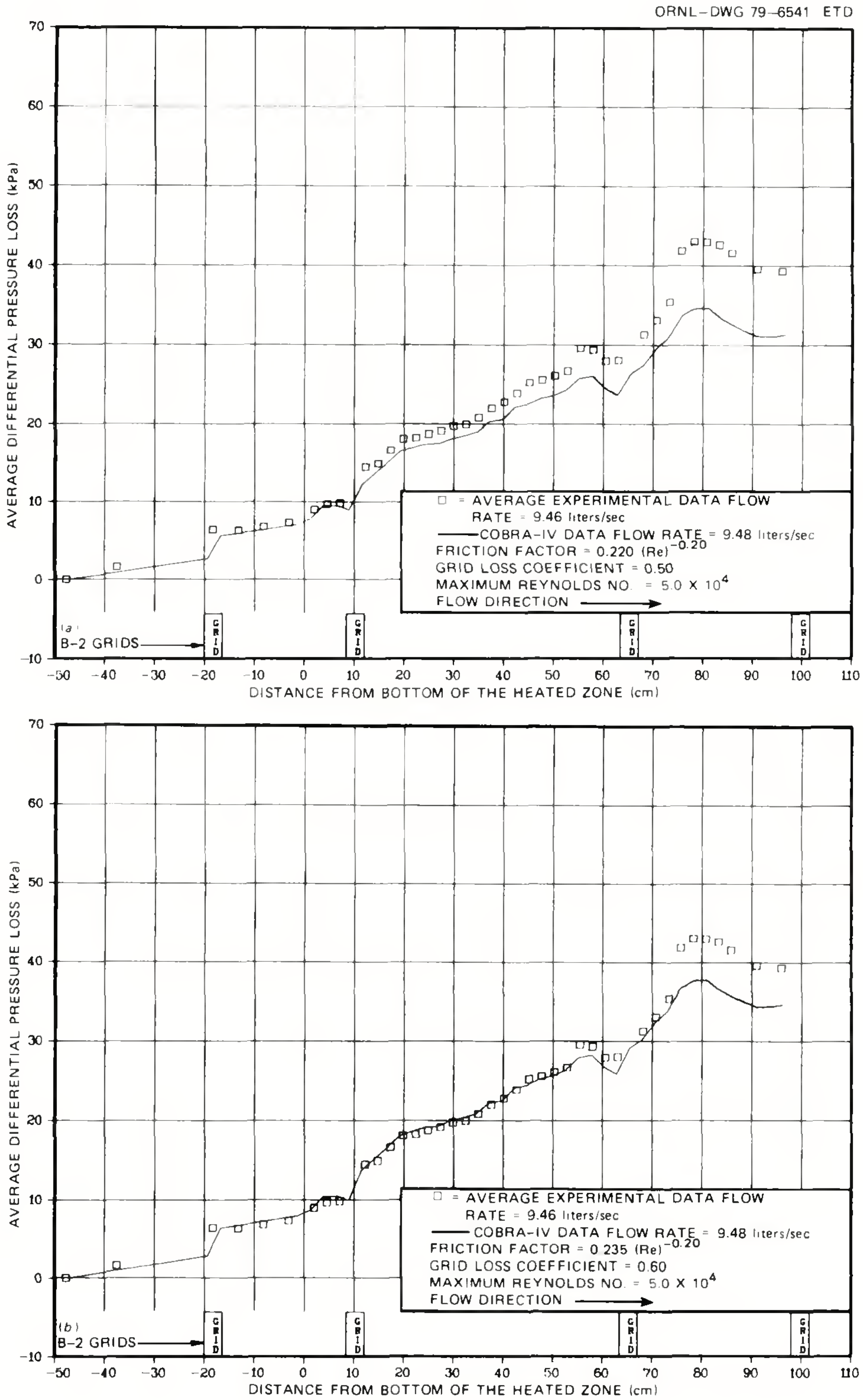



Fig. 5.27. Comparison of B-2/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 9.46 liters/sec; minimum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

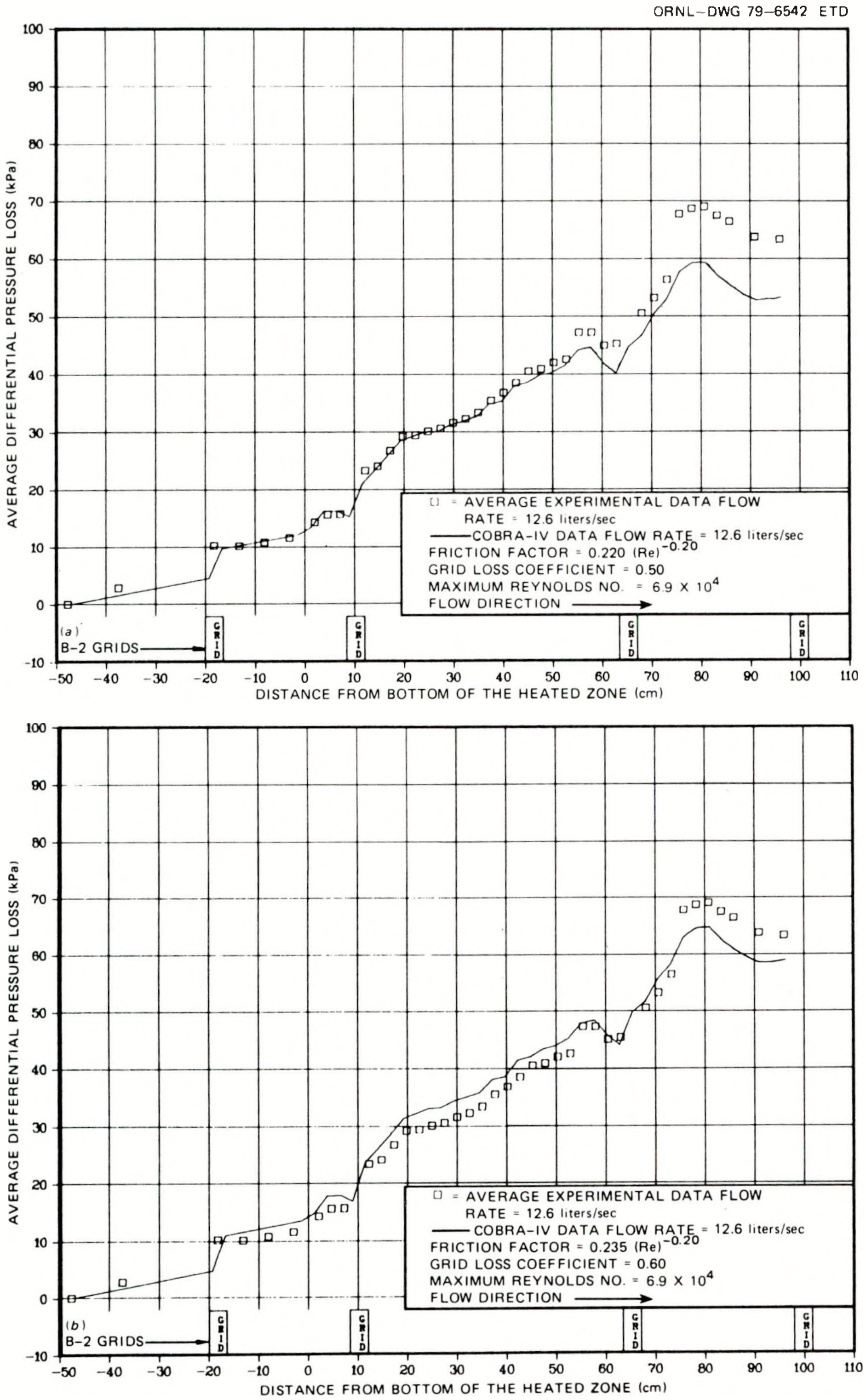



Fig. 5.28. Comparison of B-2/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 12.6 liters/sec; minimum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

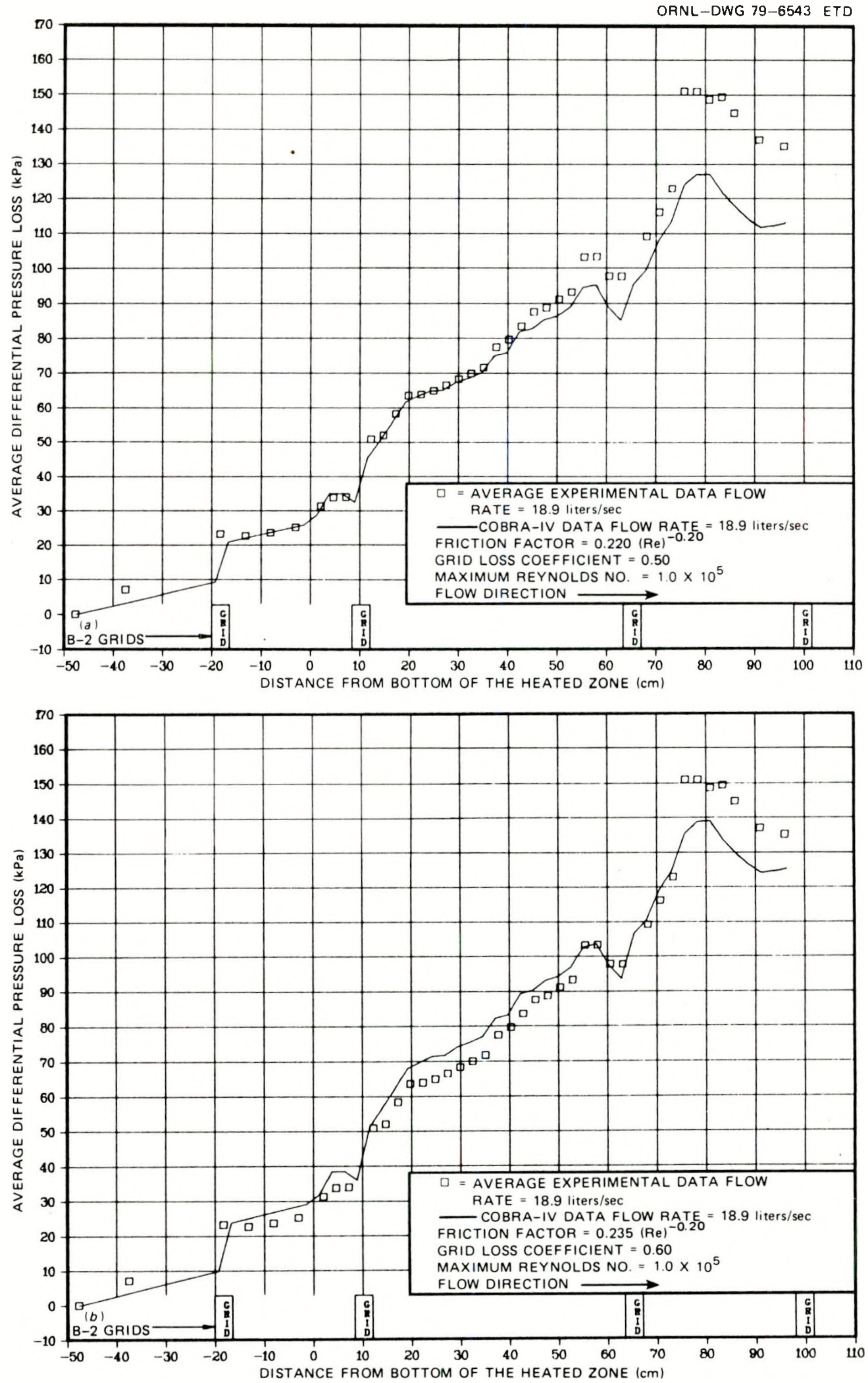



Fig. 5.29. Comparison of B-2/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 18.9 liters/sec; minimum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

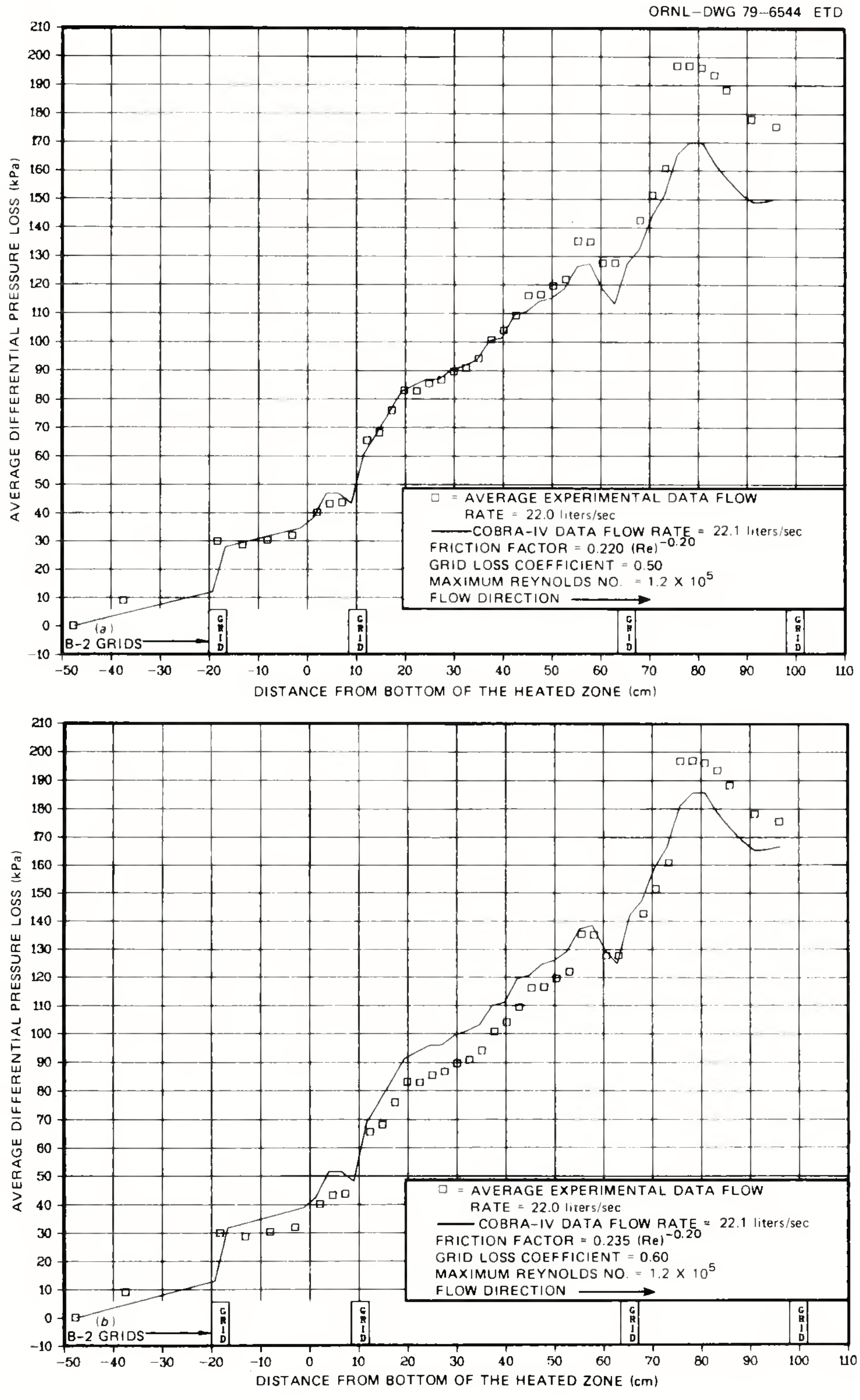



Fig. 5.30. Comparison of B-2/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 22.0 liters/sec; minimum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

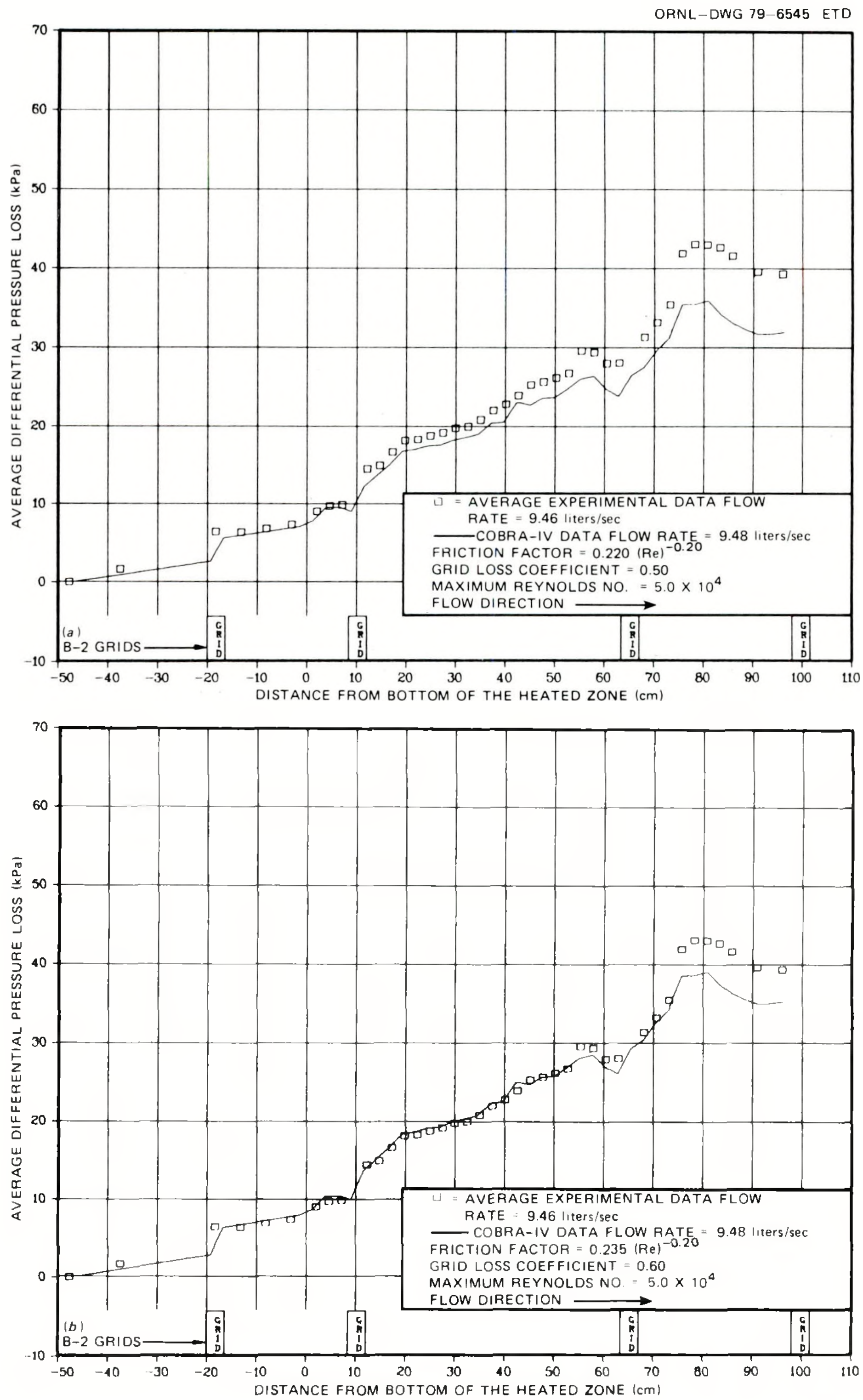



Fig. 5.31. Comparison of B-2/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 9.46 liters/sec; maximum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

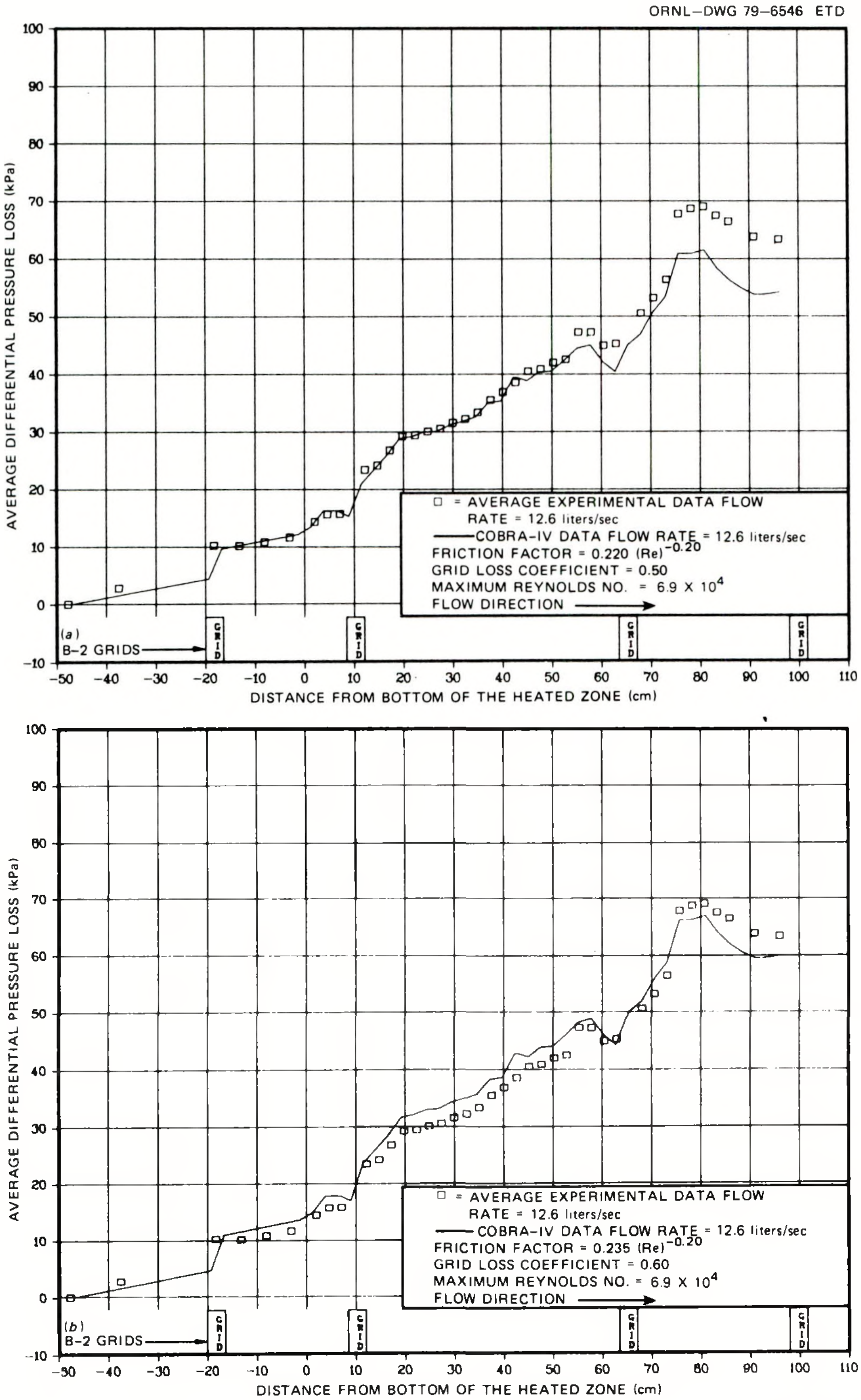



Fig. 5.32. Comparison of B-2/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 12.6 liters/sec; maximum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

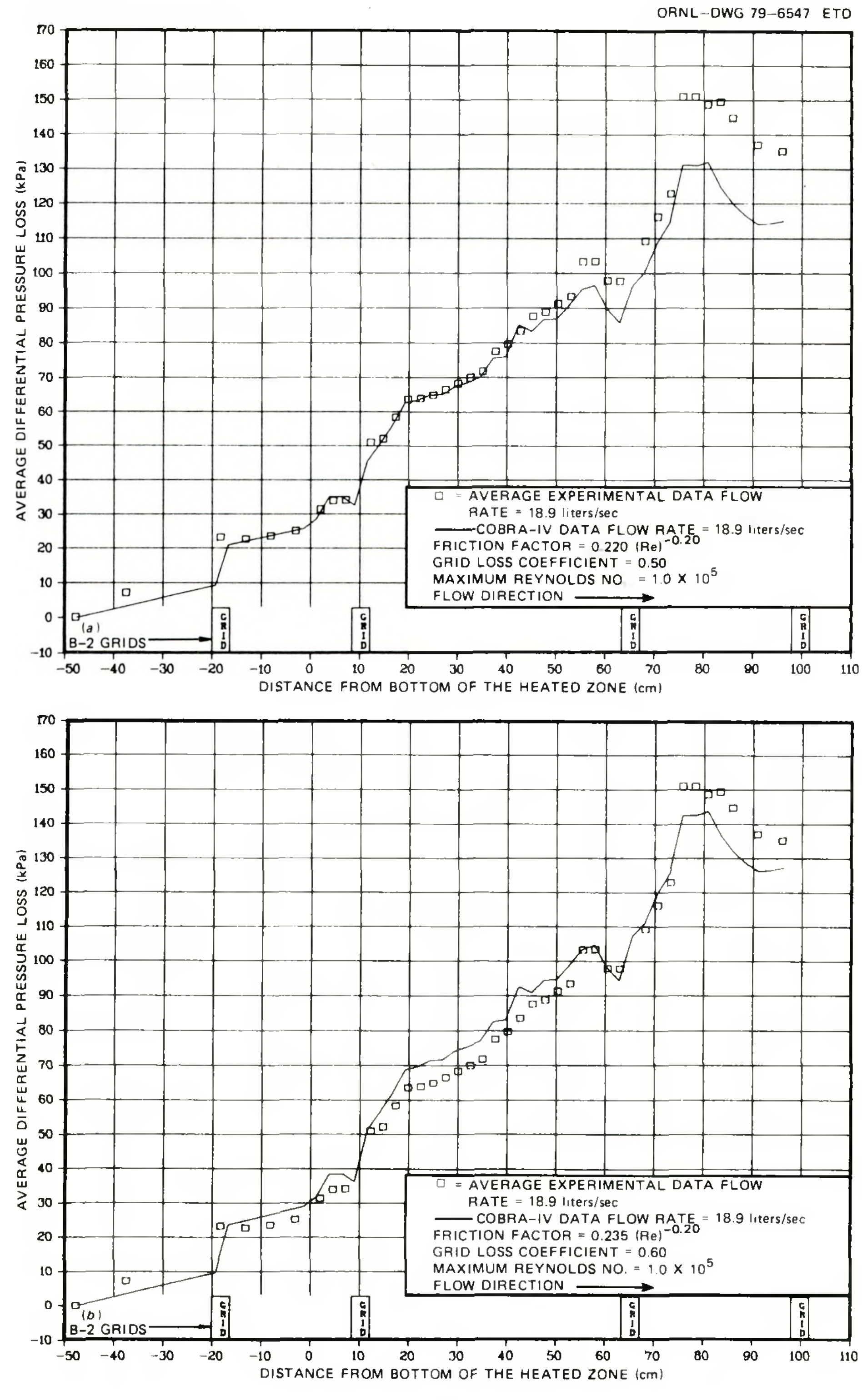



Fig. 5.33. Comparison of B-2/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 18.9 liters/sec; maximum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

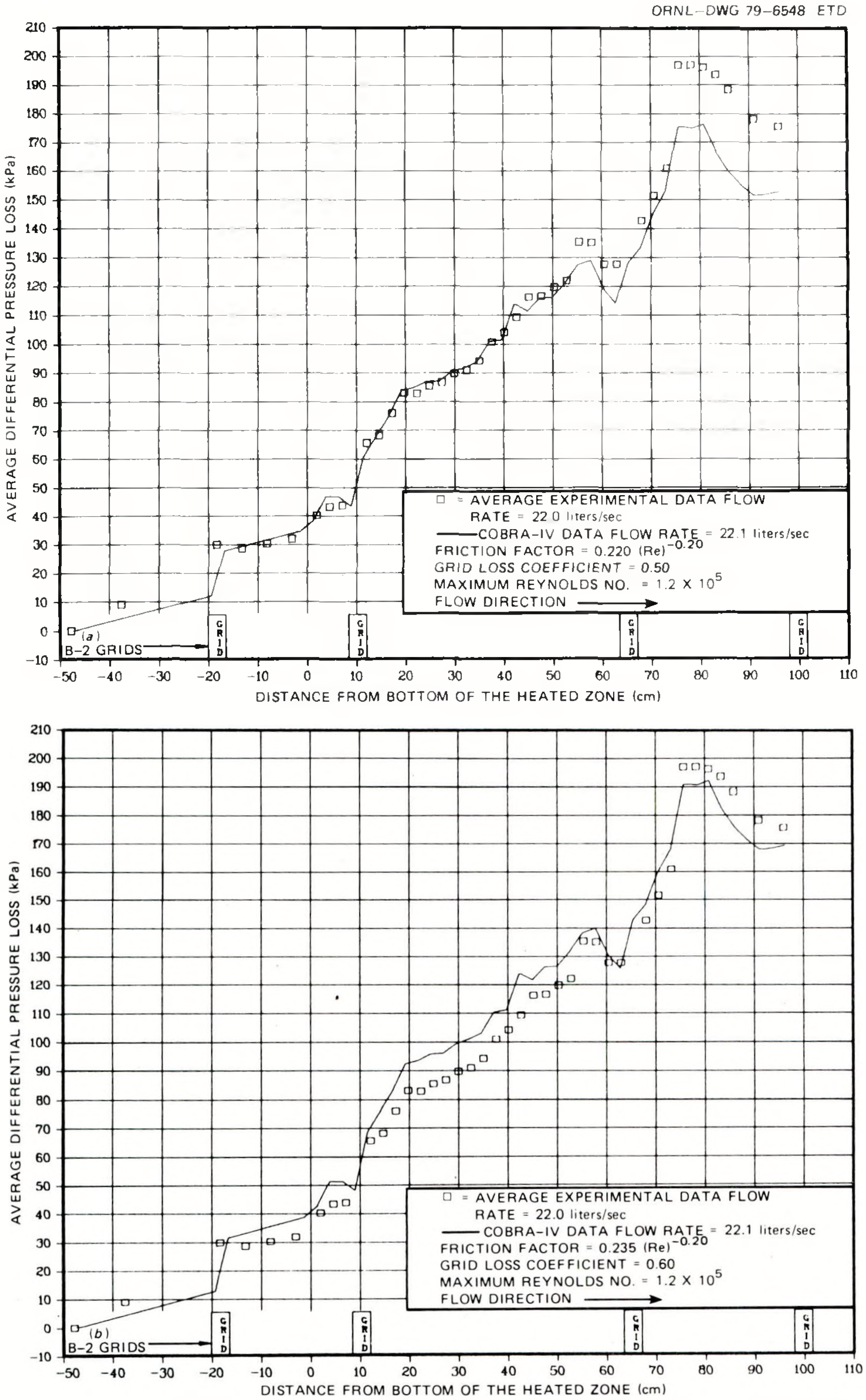



Fig. 5.34. Comparison of B-2/shroud 1 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 22.0 liters/sec; maximum restriction definition. (a) Lower-limit; (b) upper-limit correlation values.

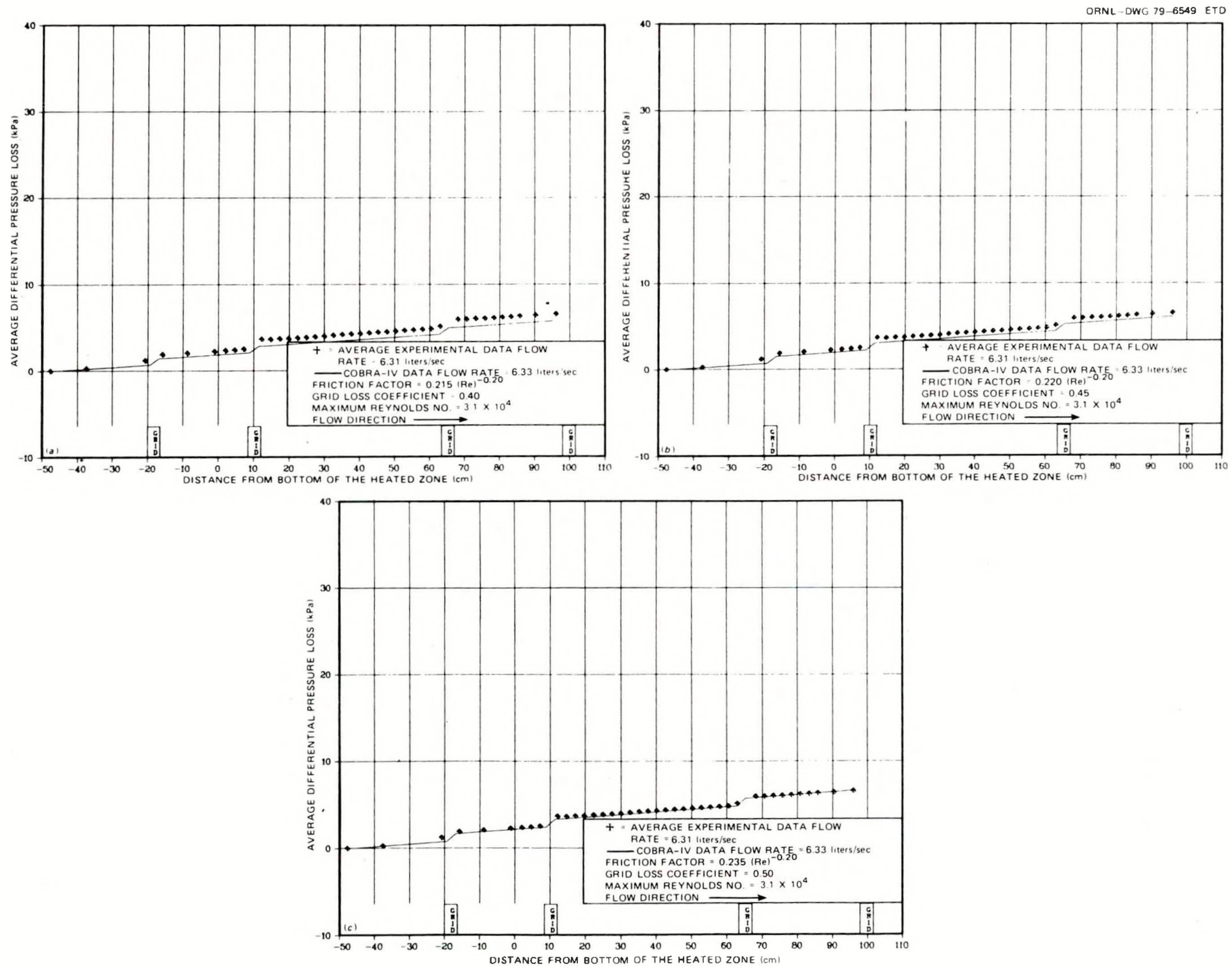



Fig. 5.35. Comparison of reference bundle/shroud 2 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 6.31 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

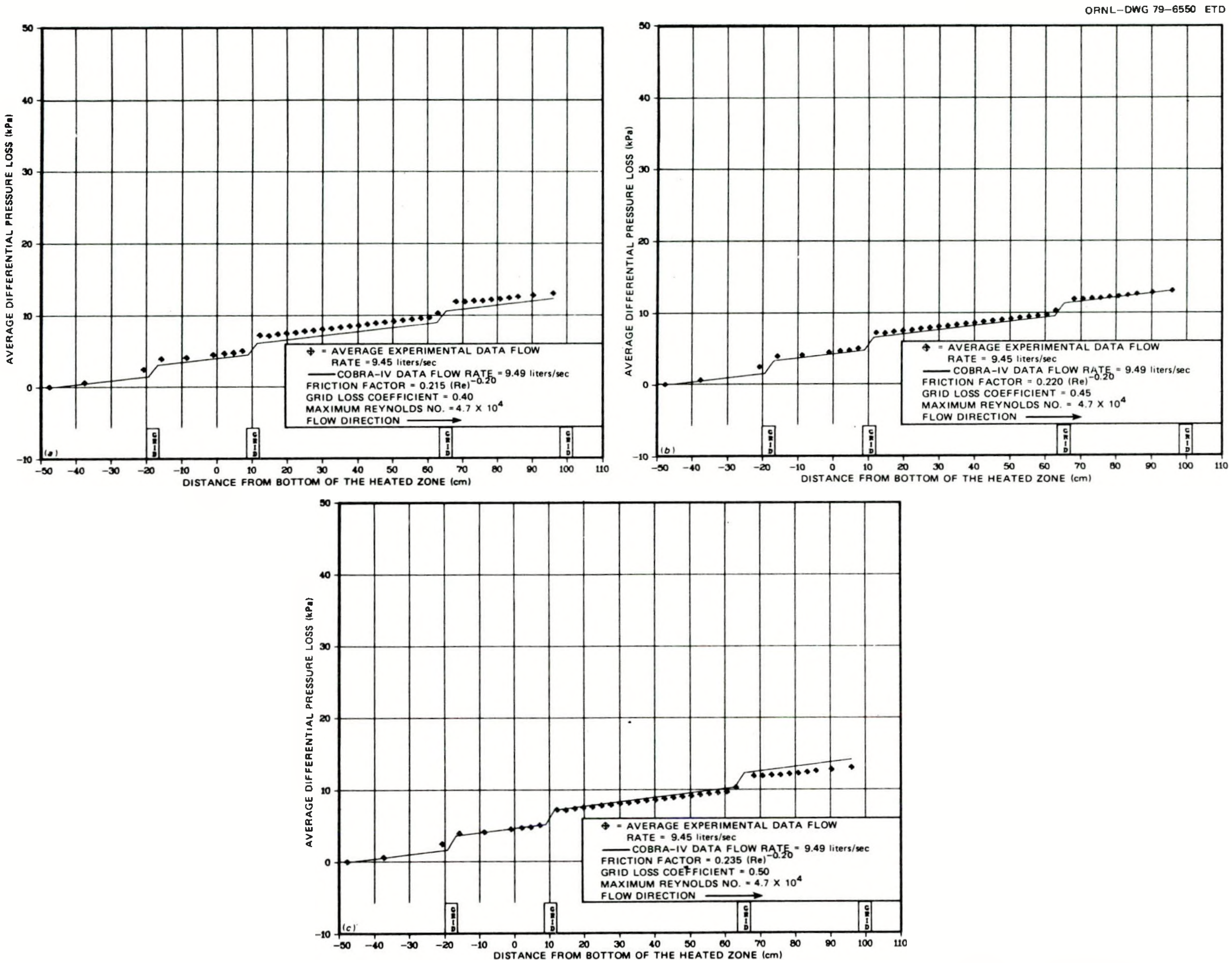



Fig. 5.36. Comparison of reference bundle/shroud 2 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 9.45 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

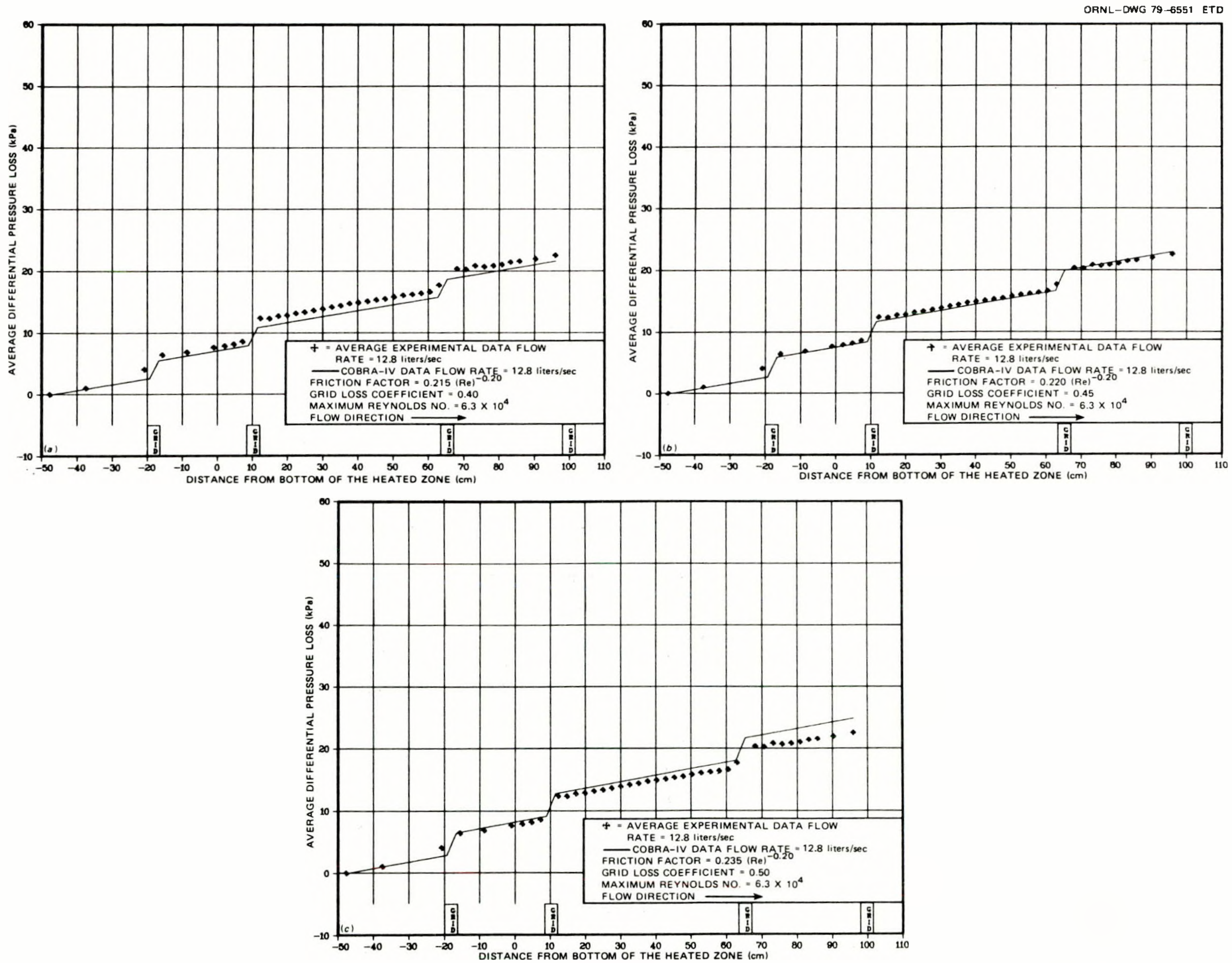



Fig. 5.37. Comparison of reference bundle/shroud 2 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 12.8 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

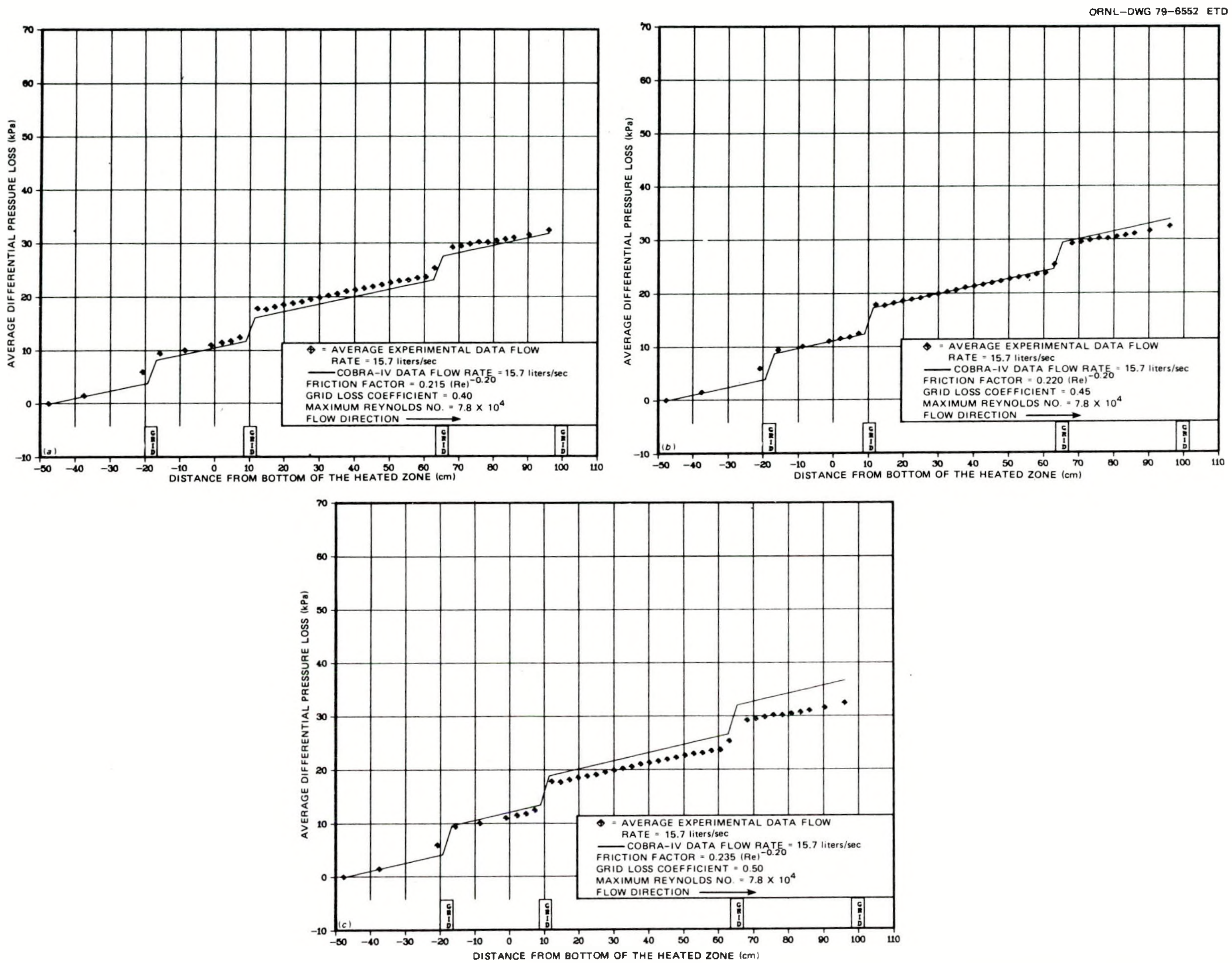



Fig. 5.38. Comparison of reference bundle/shroud 2 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 15.7 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

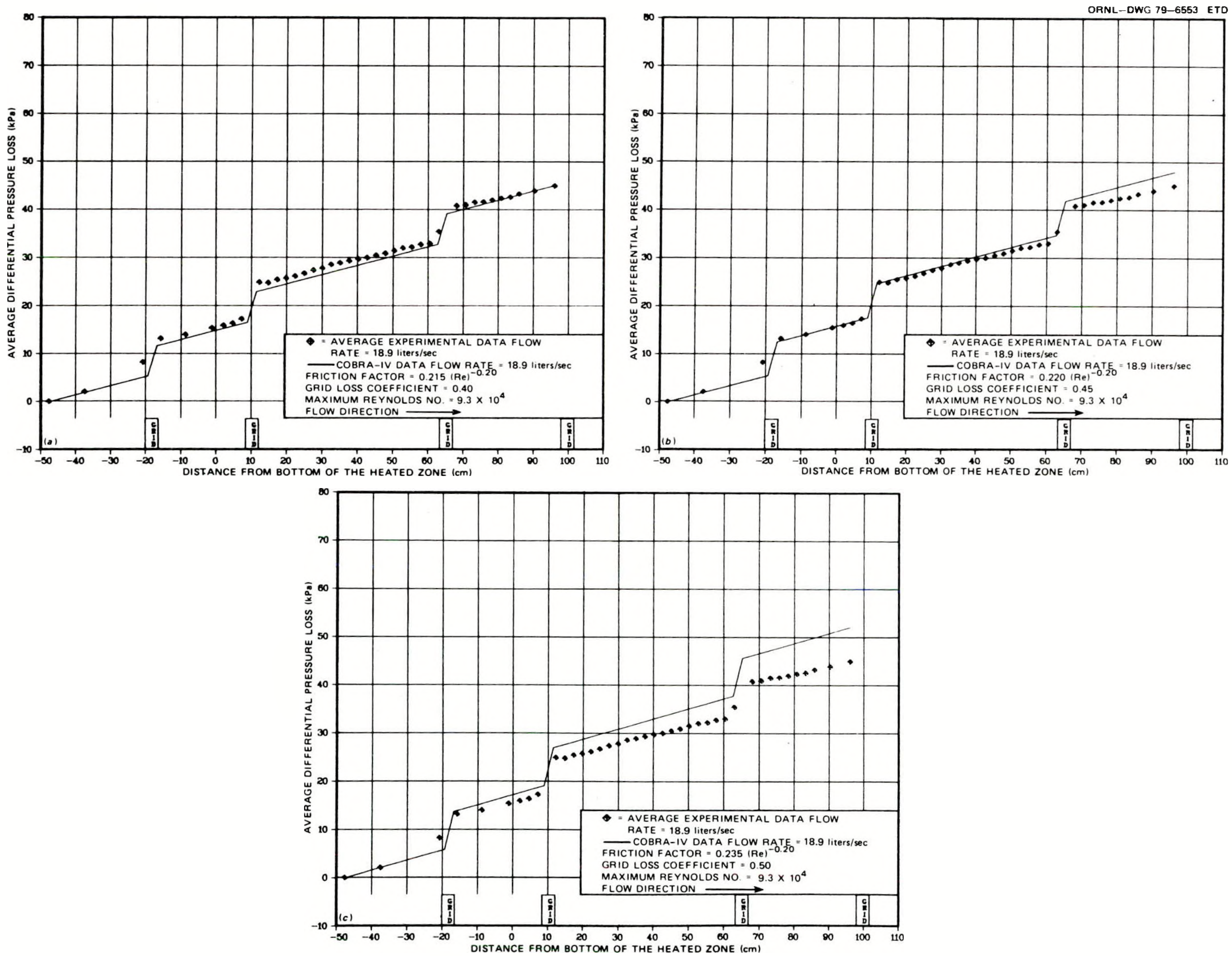



Fig. 5.39. Comparison of reference bundle/shroud 2 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 18.9 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

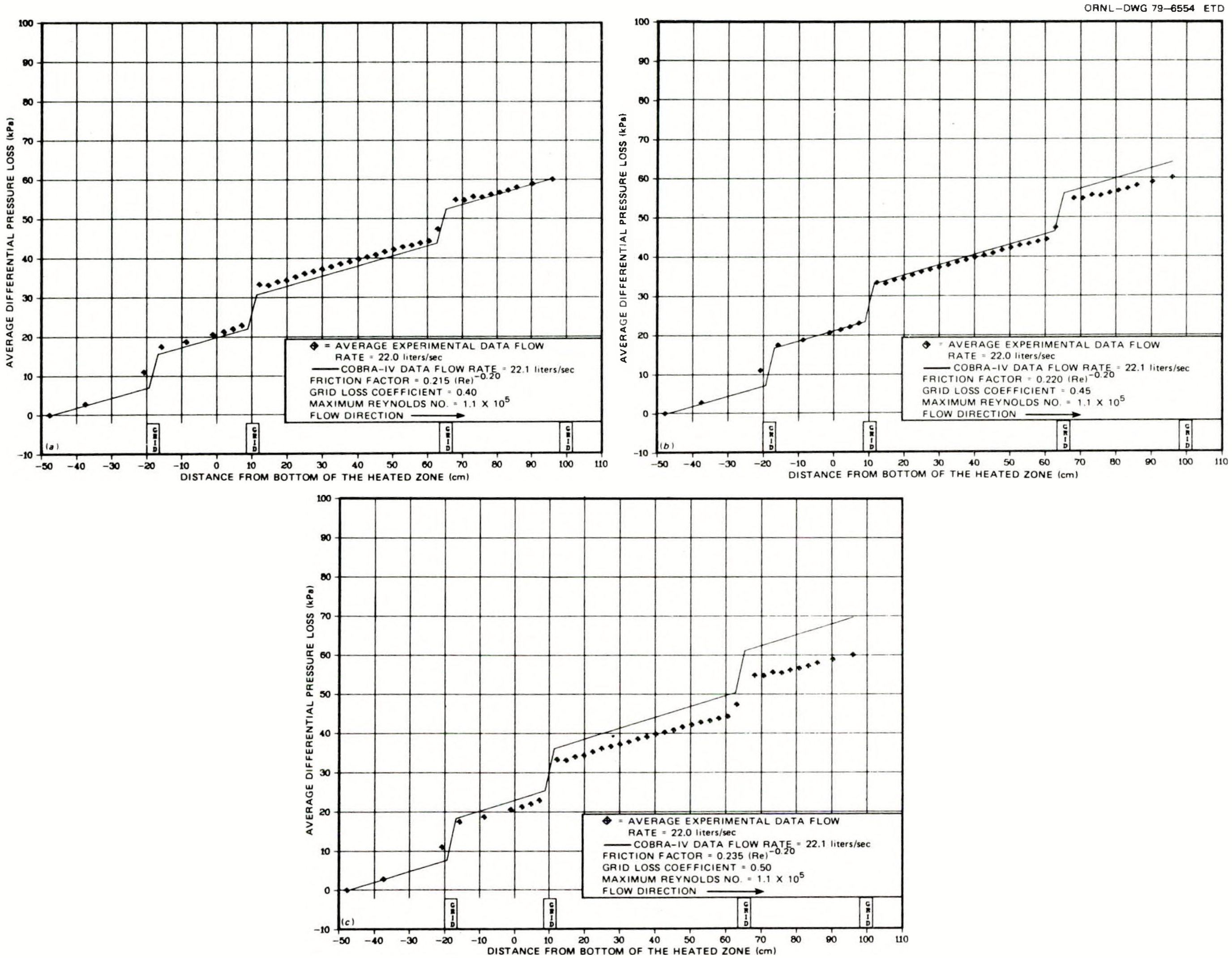



Fig. 5.40. Comparison of reference bundle/shroud 2 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 22.0 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

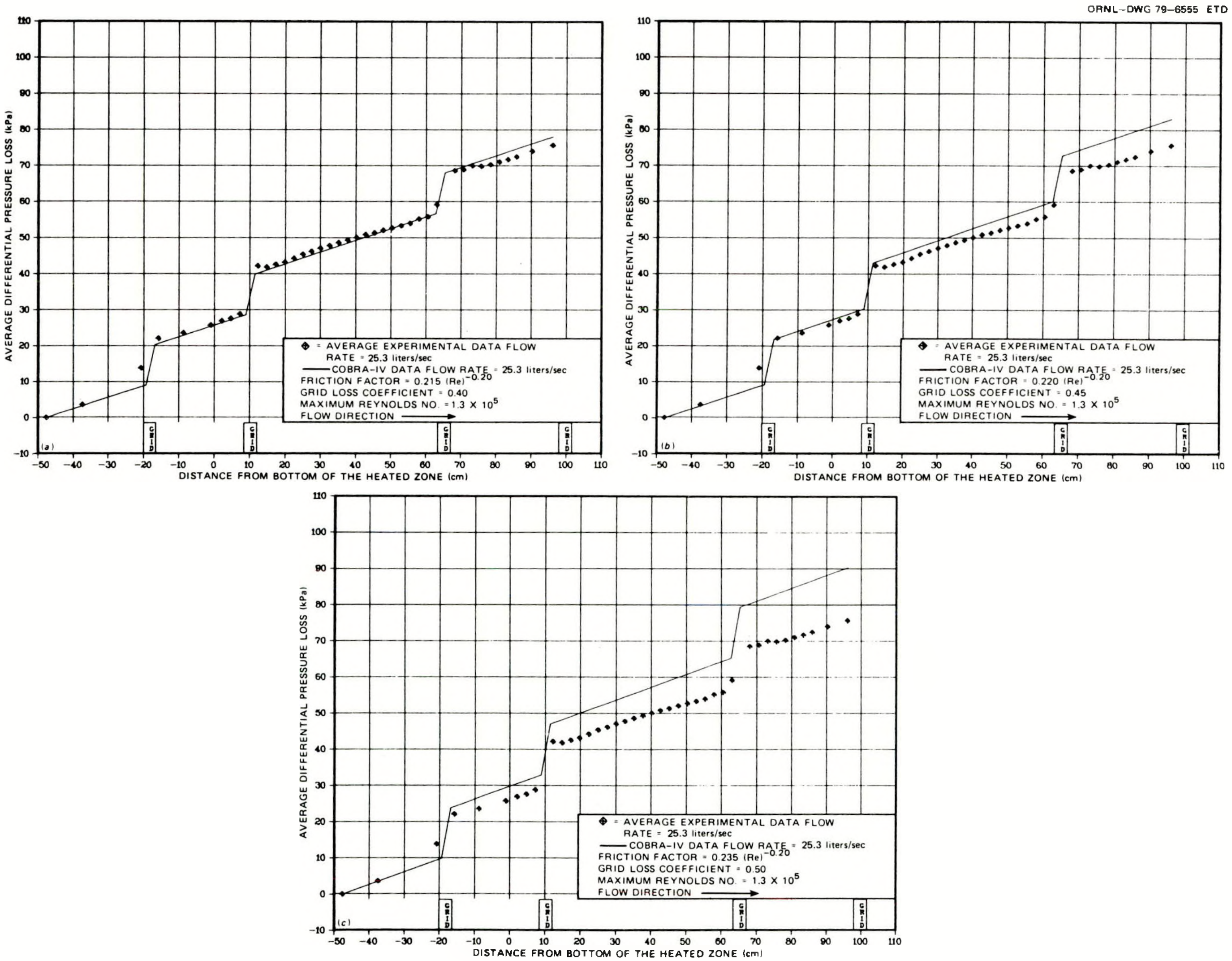



Fig. 5.41. Comparison of reference bundle/shroud 2 experimental and COBRA-IV axial pressure loss profiles; experimental flow rate = 25.3 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

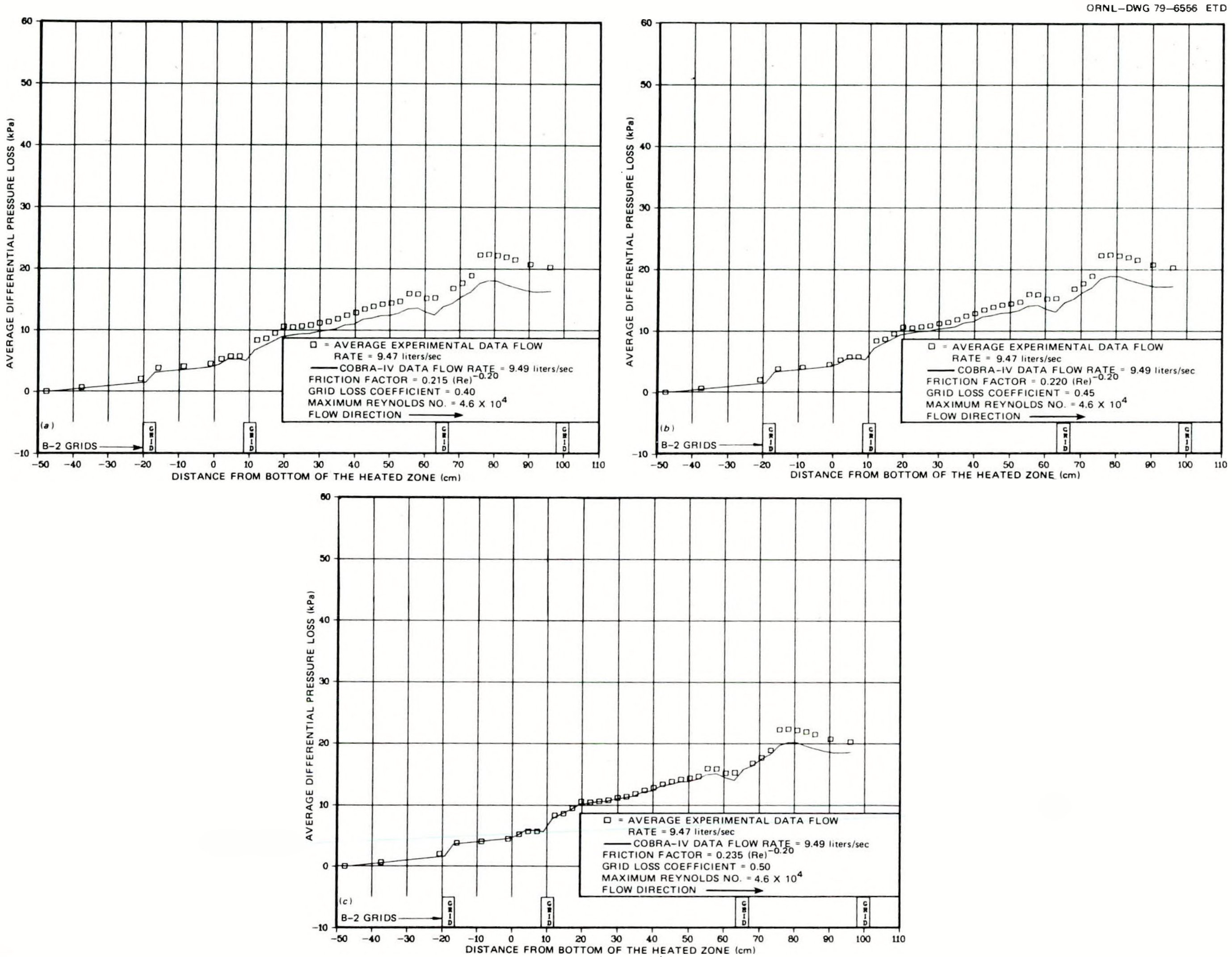



Fig. 5.42. Comparison of B-2/shroud 2 experimental and COBRA-IV axial pressure loss profiles based on the minimum restriction definition; experimental flow rate = 9.47 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

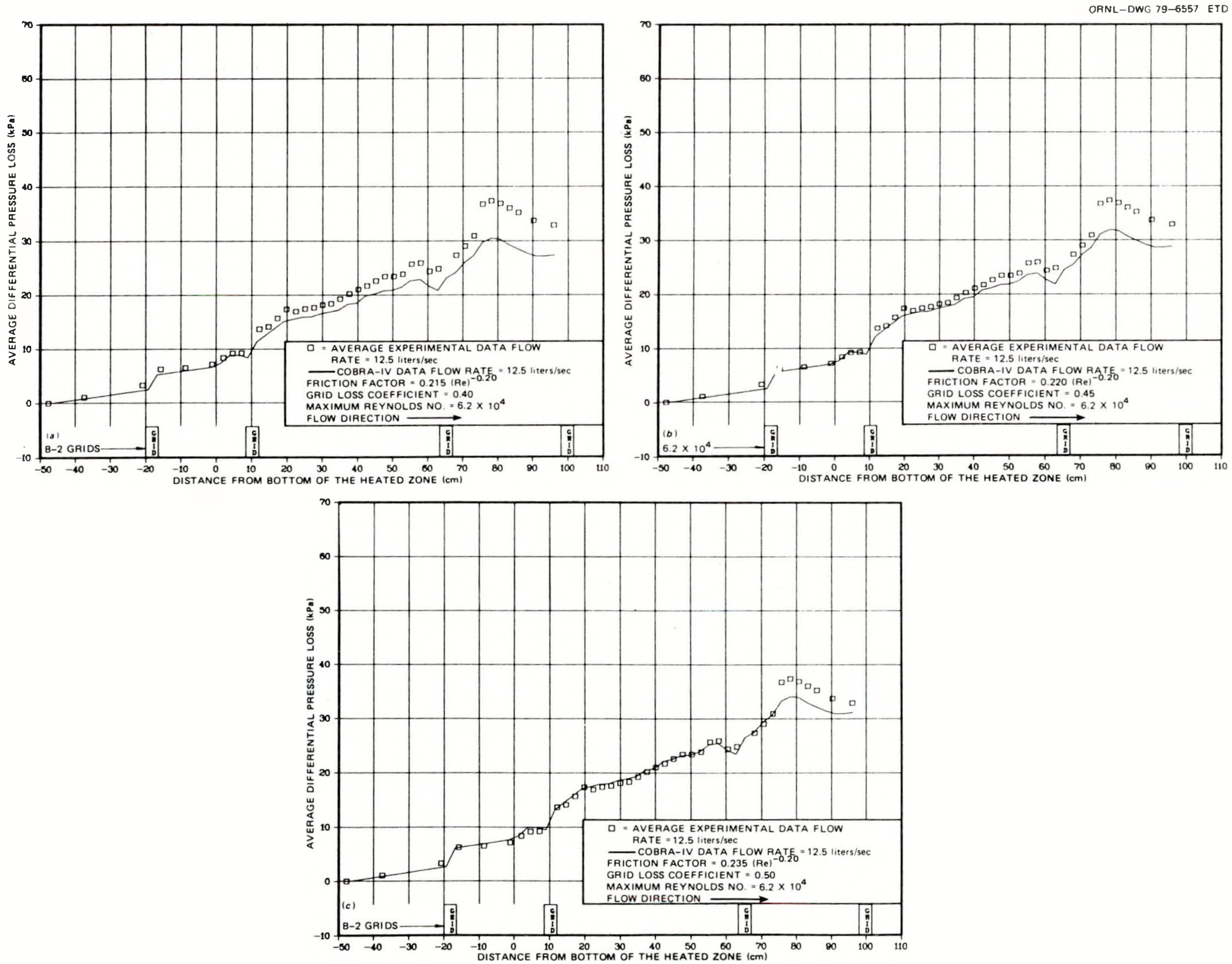



Fig. 5.43. Comparison of B-2/shroud 2 experimental and COBRA-IV axial pressure loss profiles based on the minimum restriction definition; experimental flow rate = 12.5 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

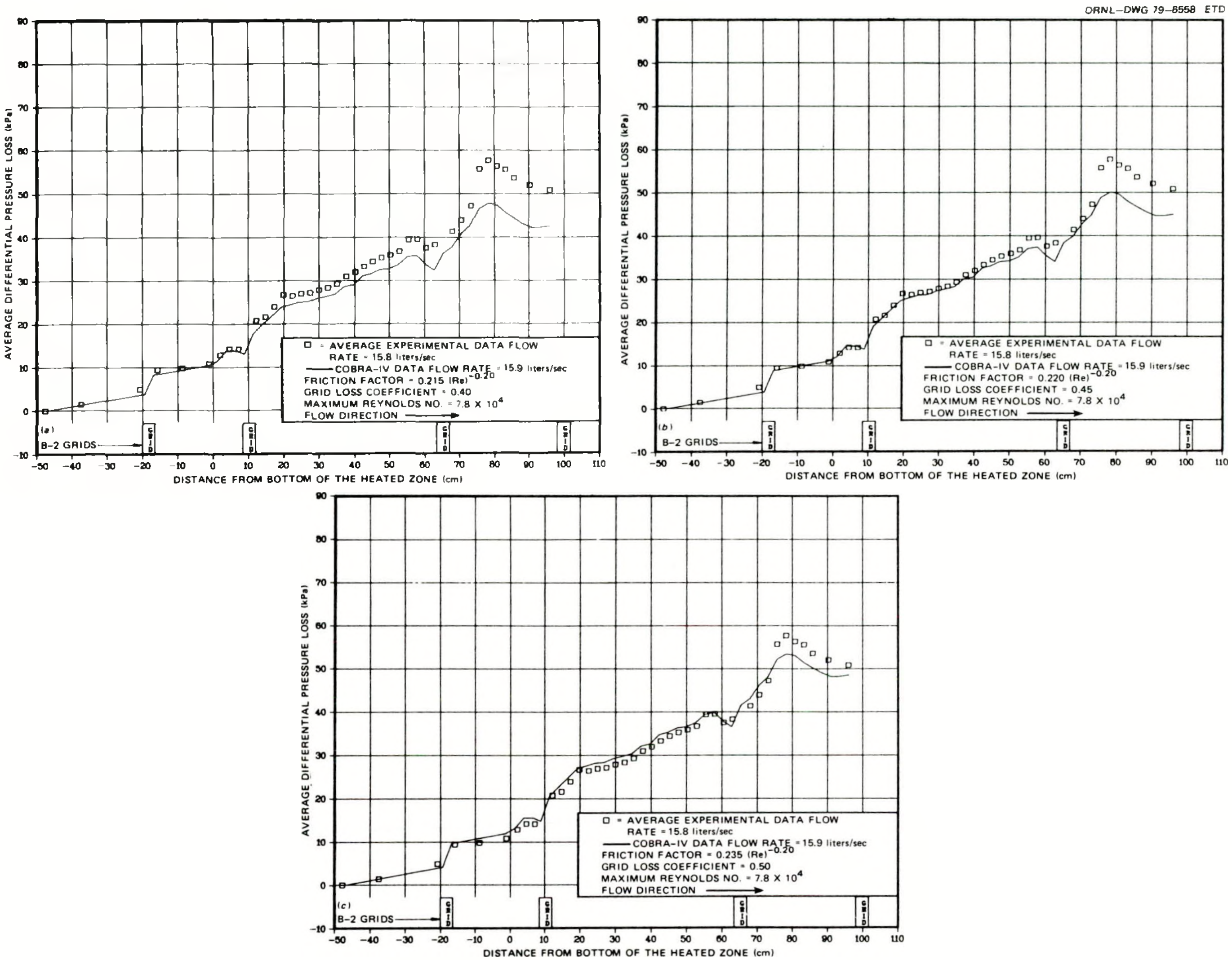



Fig. 5.44. Comparison of B-2/shroud 2 experimental and COBRA-IV axial pressure loss profiles based on the minimum restriction definition; experimental flow rate = 15.8 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

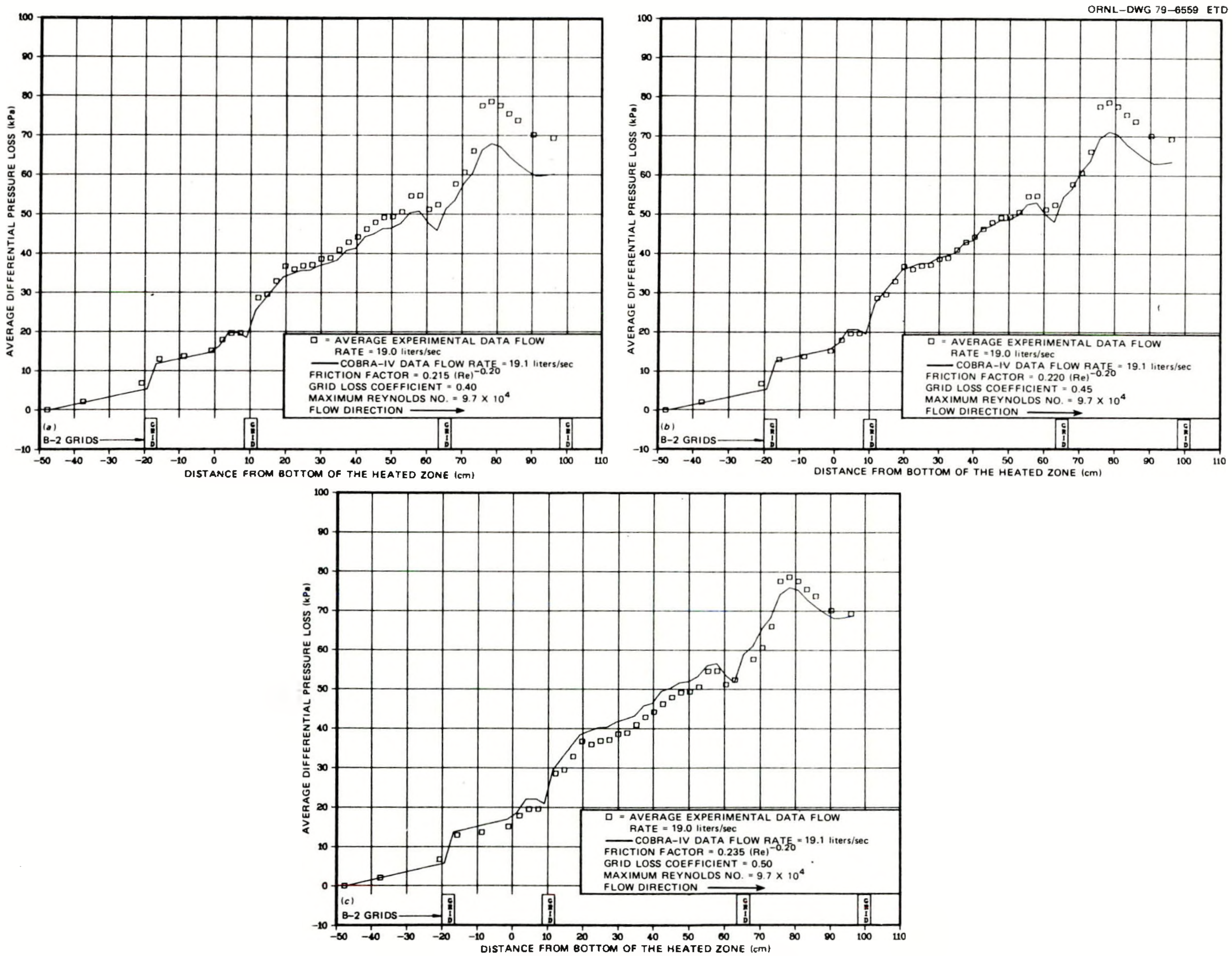



Fig. 5.45. Comparison of B-2/shroud 2 experimental and COBRA-IV axial pressure loss profiles based on the minimum restriction definition; experimental flow rate = 19.0 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

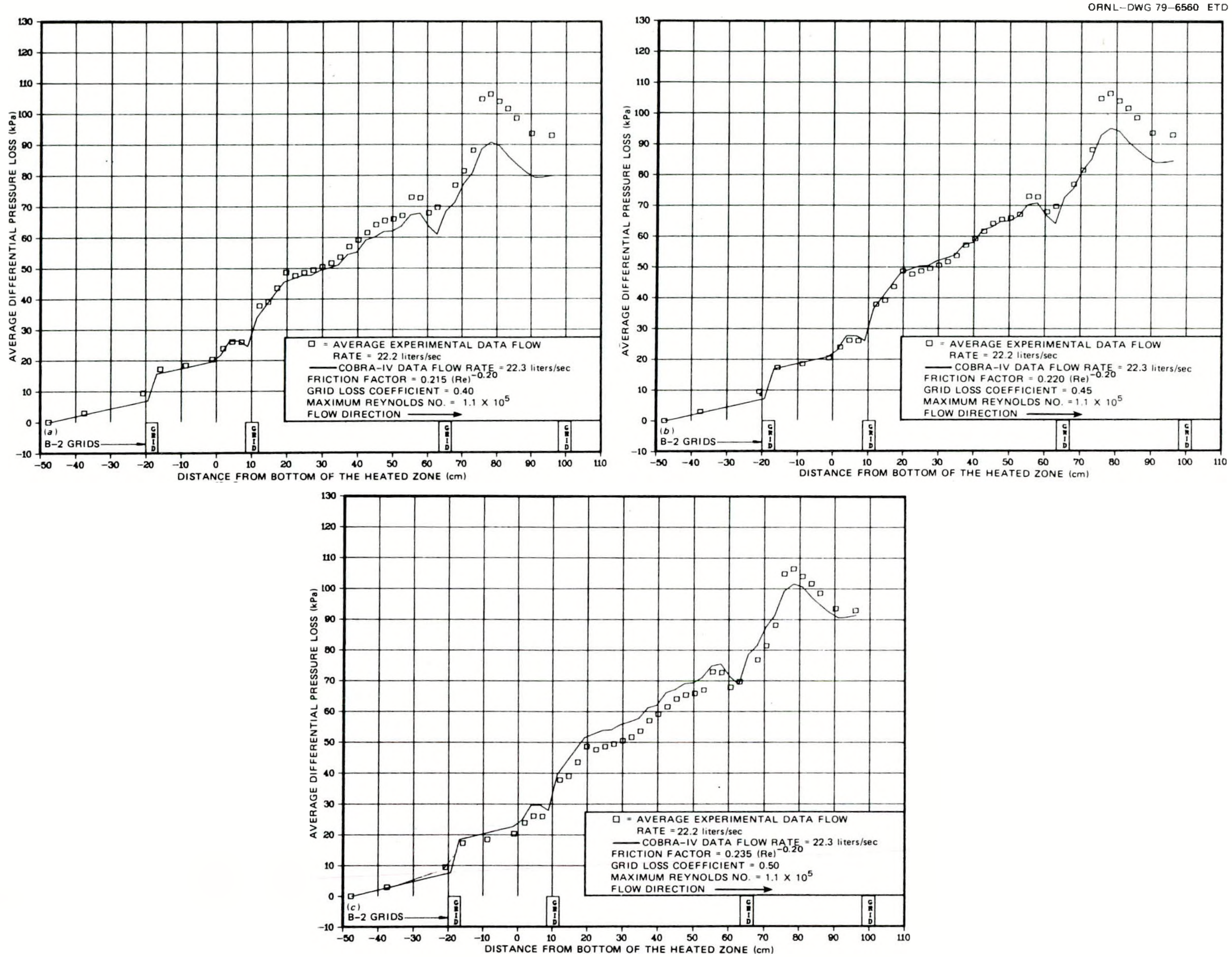



Fig. 5.46. Comparison of B-2/shroud 2 experimental and COBRA-IV axial pressure loss profiles based on the minimum restriction definition; experimental flow rate = 22.2 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

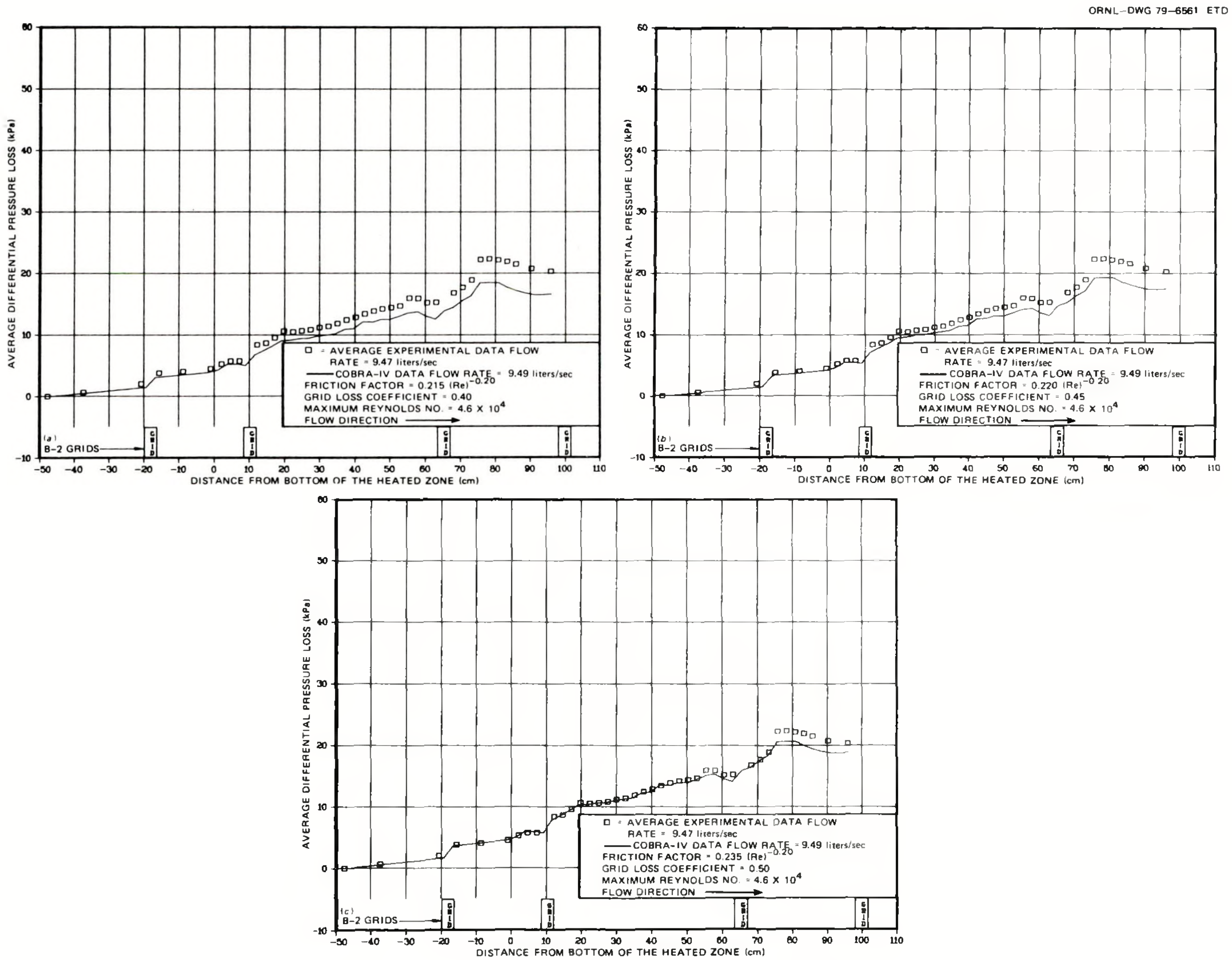



Fig. 5.47. Comparison of B-2/shroud 2 experimental and COBRA-IV axial pressure loss profiles based on the maximum restriction definition; experimental flow rate = 9.47 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

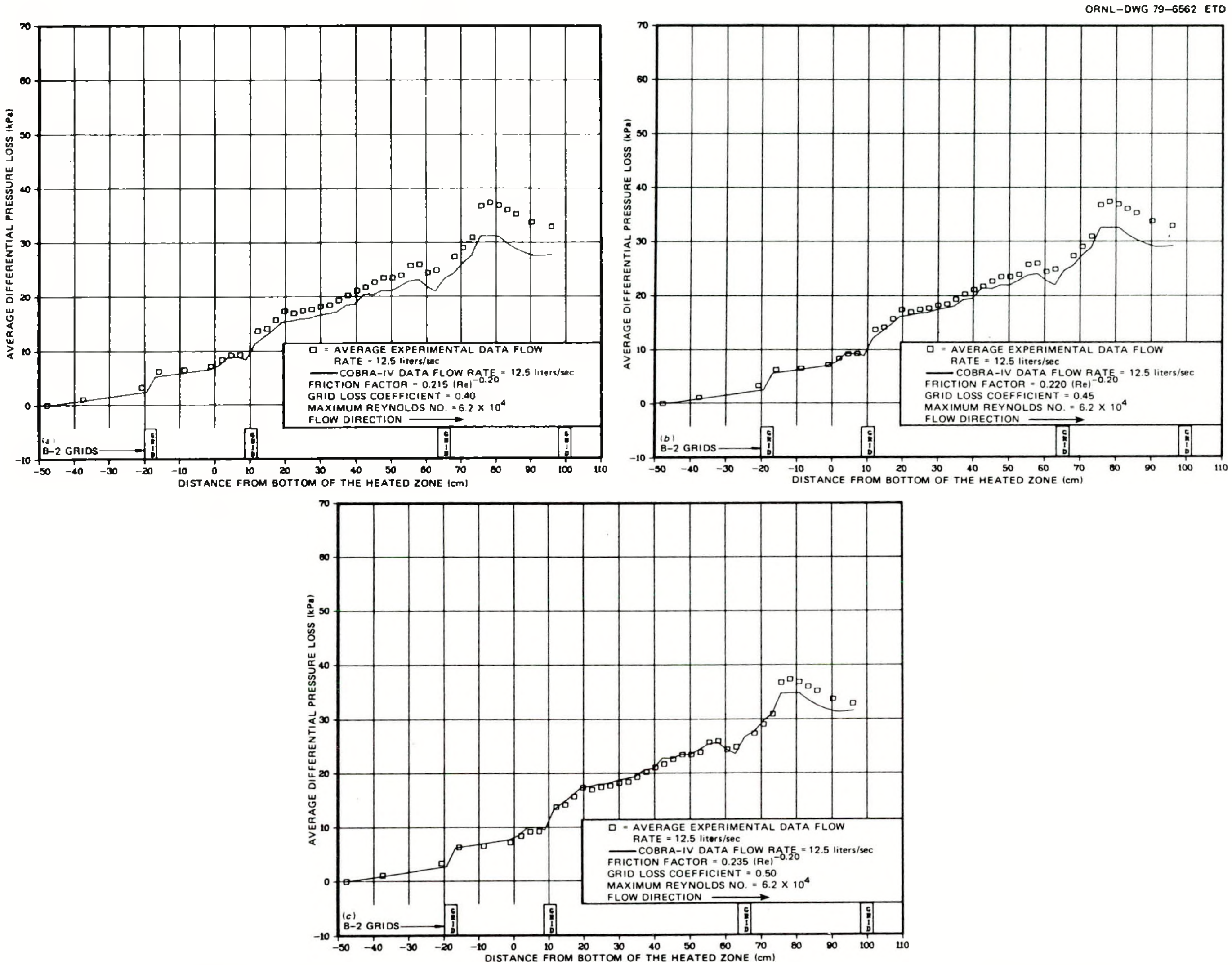



Fig. 5.48. Comparison of B-2/shroud 2 experimental and COBRA-IV axial pressure loss profiles based on the maximum restriction definition; experimental flow rate = 12.5 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

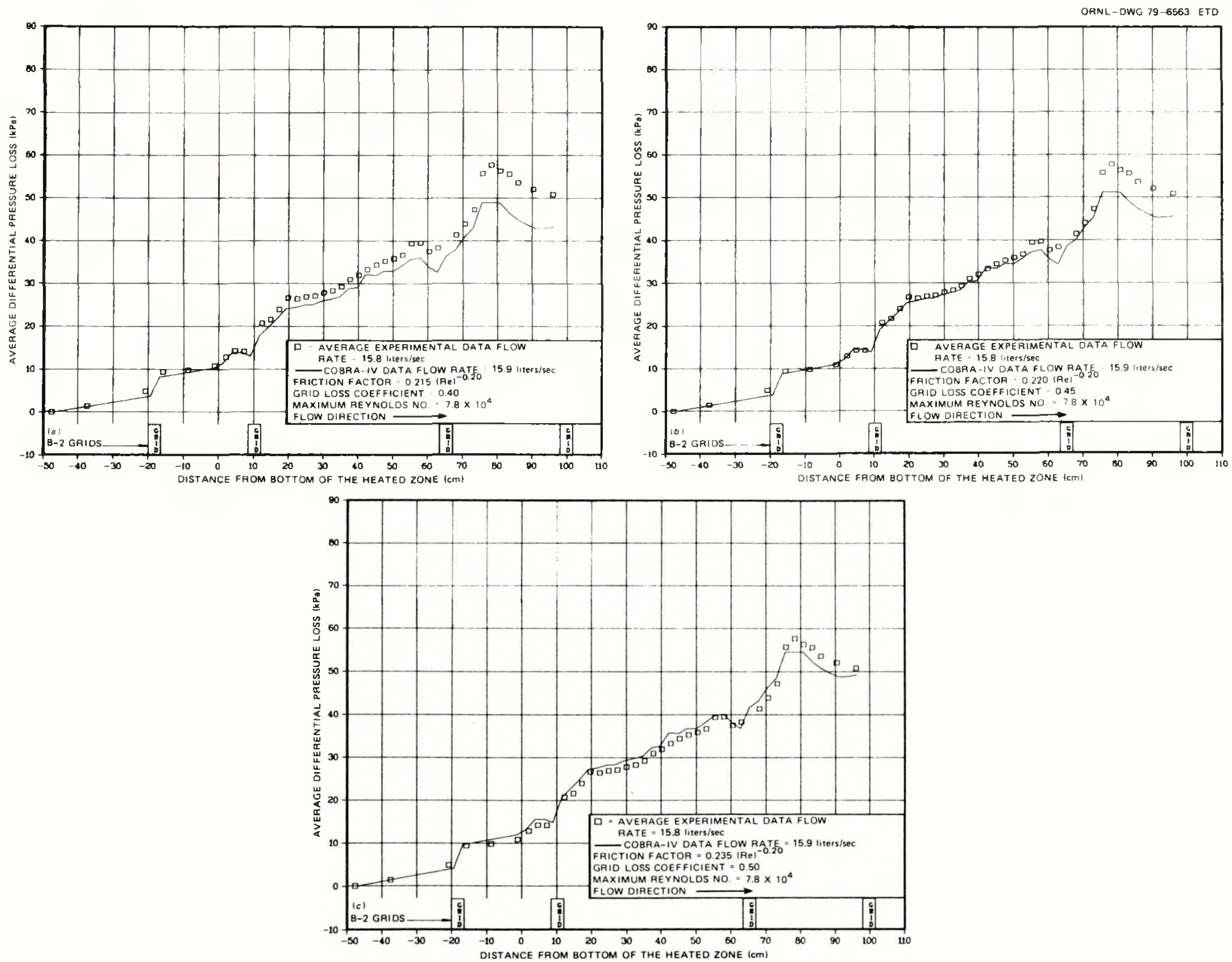





Fig. 5.49. Comparison of B-2/shroud 2 experimental and COBRA-IV axial pressure loss profiles based on the maximum restriction definition; experimental flow rate = 15.8 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

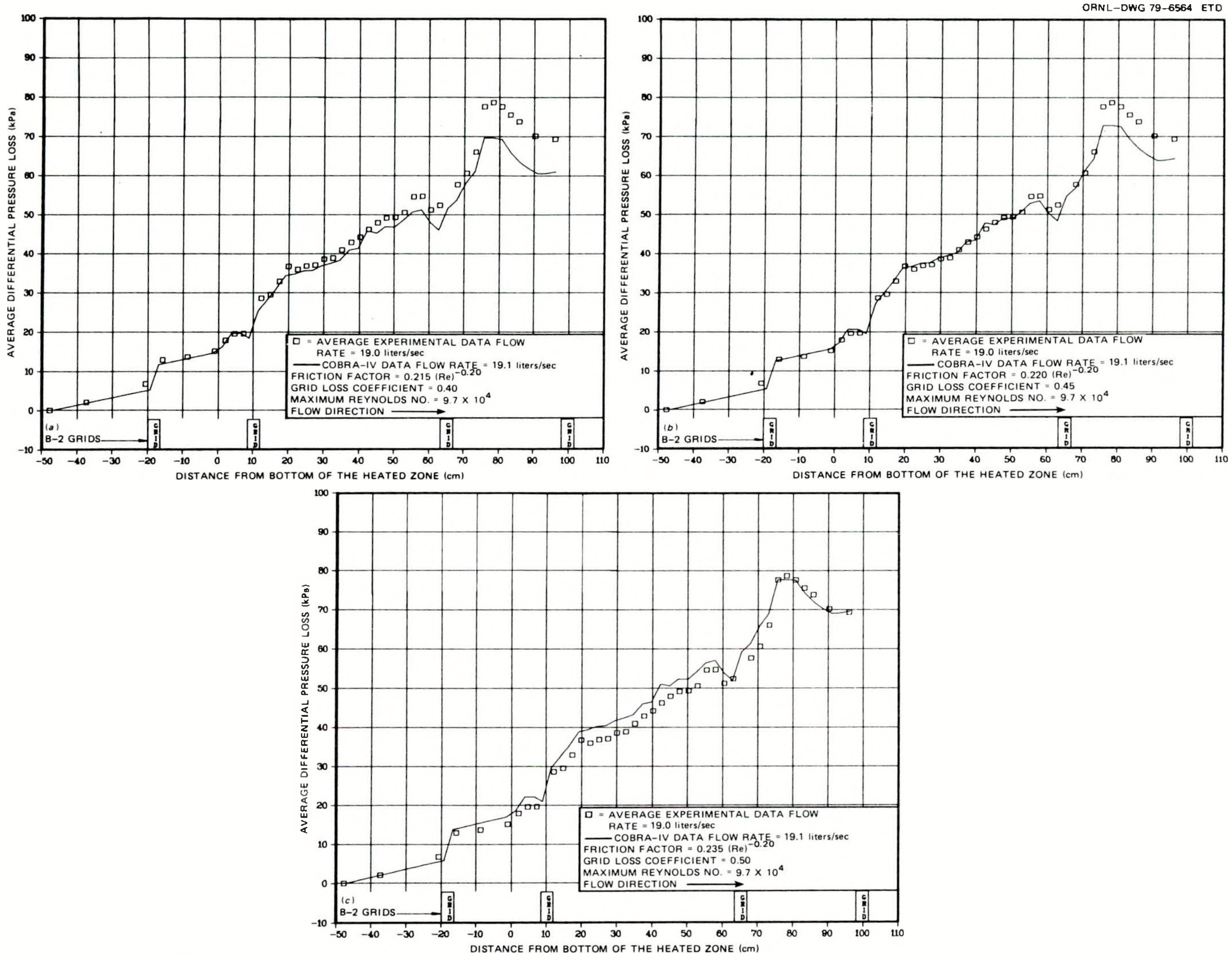



Fig. 5.50. Comparison of B-2/shroud 2 experimental and COBRA-IV axial pressure loss profiles based on the maximum restriction definition; experimental flow rate = 19.0 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

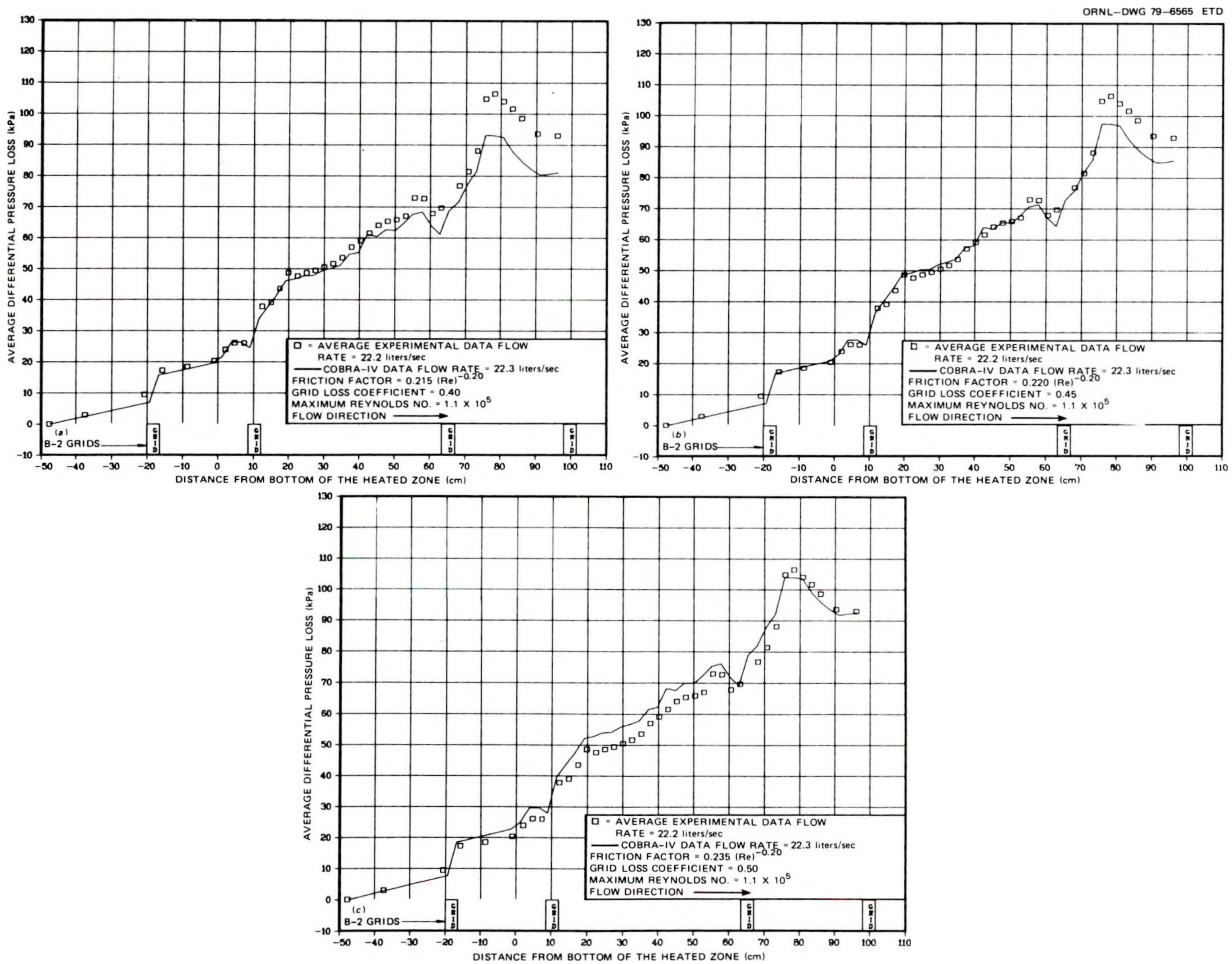



Fig. 5.51. Comparison of B-2/shroud 2 experimental and COBRA-IV axial pressure loss profiles based on the maximum restriction definition; experimental flow rate = 22.2 liters/sec. (a) Lower, (b) middle, and (c) upper correlation values.

# 6. CONCLUSIONS

One of the MRBT program objectives is to examine the behavior of flow resistance as a function of channel blockage. This was accomplished for B-1 and B-2 by measuring the pressure loss characteristics of those bundles as a function of flow rate (Reynolds modulus) in both the pretest and posttest conditions. These measurements were conducted in an existing flow loop, using water as the test fluid. Since these measurements did not include detailed velocity surveys (i.e., they did not provide cross-flow information about deformed regions), the resulting data do not provide more than a first-order approximation of increased flow resistance as a function of bundle-averaged flow blockage. These experimental and computation analyses in no way purport to evaluate the thermal performance of bundles with subchannel blockages. The experimental data presented are subject to significant uncertainties. Hence, these flow tests are more the proof-of-principle type of experiment rather than being of benchmark quality.

In regard to comparisons of these experimentally derived data with COBRA-IV calculated data, several observations have been made. First, a bundle-averaged approach in modeling pressure losses has been used with considerable success in determining the characteristic shapes of burst bundle pressure loss profiles. Secondly, the absolute magnitudes of these calculated pressure loss profiles were found to be very dependent upon the friction factor correlations and spacer grid pressure loss coefficients used in the calculations. The percent of variation in these correlations found necessary to closely model experimental pressure losses with COBRA-IV (±5% for friction factors, ±15% for grid spacer pressure loss coefficients) is indicative of the precision to which reported flow areas, flow rates, and pressure measurements could be determined under the available experimental conditions.

Concluding, COBRA-IV and the bundle-averaged restriction representation constitute a viable computational technique for predicting pressure losses in this type of hydraulic system. More precise experimental data are needed, however, to determine better and more general representations of friction factors and grid loss coefficients for the laminar, transition, and turbulent flow regimes. If more precise representations for these correlations were available, COBRA-IV could be used to predict pressure loss profiles for similar hydraulic systems that are more representative of an in-core reactor fuel element.

## 7. ACKNOWLEDGMENTS

The author is grateful to the many individuals who gave of their time, patience, and advice. In particular recognition is given to P. H. Hayes, E. L. Armstrong, J. L. Crowley, C. D. Griffies, and R. H. Chapman for their guidance in designing the equipment; to A. W. Longest, E. L. Biddle, C. D. Griffies, J. N. Money, C. Cross, and W. H. Glover for assisting with the flow tests; to D. M. Lister and P. A. Jallouk for their assistance in setting up COBRA-IV; and to J. E. Hardy and J. C. Conklin for reviewing this report.

# 8. REFERENCES


1. R. H. Chapman, *Multirod Burst Test Program Quarterly Progress Report for April—June 1977*, ORNL/NUREG/TM-135 (December 1977).
2. C. L. Wheeler, *COBRA-IV-I: An Interim Version of COBRA for Thermal-Hydraulic Analysis of Rod Bundle Nuclear Fuel Elements and Cores*, BNWL-1962 (March 1976).
3. R. H. Chapman et al., *Bundle B-1 Test Data, Multirod Burst Test Program*, ORNL/NUREG/TM-322 (June 1979).
4. R. H. Chapman et al., *Bundle B-2 Test Data, Multirod Burst Test Program*, ORNL/NUREG/TM-337 (August 1979).
5. R. H. Chapman, *Multirod Burst Test Program Progress Report for July—December 1977*, ORNL/NUREG/TM-200 (NUREG/CR-0103) (June 1978).
6. A. N. de Stordeur, "Drag Coefficients for Fuel Element Spacers," *Nucleonics* 19(6): 74—79 (June 1961).
7. T. B. Drew, E. C. Koo, and W. H. McAdams, "The Friction Factor for Clean Round Pipes," *Trans. Am. Inst. Chem. Eng.* 28: 56 (1932).
8. L. S. Tong, "Pressure Drop Performance of a Rod Bundle," *Symposium on Heat Transfer in Rod Bundles*, p. 65, American Society of Mechanical Engineers, New York, 1968.
9. J. Marek, K. Maubach, and K. Rehme, "Heat Transfer and Pressure Drop Performance of Rod Bundles Arranged in Square Arrays," *Int. J. Heat Mass Transfer* 16(12): 2215—2228 (December 1973).

# APPENDICES

# Appendix A

## B-1/SHROUD 1 BUNDLE-AVERAGED GEOMETRY DATA, MINIMUM RESTRICTION DEFINITION

The data in Appendix A represent the input from card groups 5 and 6 as required by ref. 2 for the B-1/shroud 1 COBRA-IV model based on the minimum restriction definition.

Table A.1. Shroud flow area reductions for the B-1/shroud 1 COBRA-IV model based on the minimum restriction definition

| AXL[a] | FRACTIONAL SHROUD FLOW AREA |
|---|---|
| -47.473 | 1.000 |
| 0.000 | 0.983 |
| 1.800 | 0.915 |
| 3.300 | 0.853 |
| 5.200 | 0.851 |
| 8.900 | 0.947 |
| 11.800 | 0.940 |
| 14.100 | 0.797 |
| 15.400 | 0.766 |
| 17.300 | 0.763 |
| 18.900 | 0.729 |
| 20.100 | 0.719 |
| 20.600 | 0.728 |
| 22.300 | 0.727 |
| 23.900 | 0.711 |
| 25.500 | 0.715 |
| 26.500 | 0.709 |
| 28.100 | 0.716 |
| 29.700 | 0.748 |
| 30.700 | 0.764 |
| 33.200 | 0.787 |
| 34.500 | 0.786 |
| 36.600 | 0.790 |
| 38.100 | 0.779 |
| 39.700 | 0.734 |
| 40.800 | 0.723 |
| 42.900 | 0.736 |
| 44.700 | 0.701 |
| 46.700 | 0.686 |
| 47.500 | 0.688 |
| 48.600 | 0.715 |
| 50.400 | 0.730 |
| 52.400 | 0.756 |
| 54.000 | 0.782 |
| 55.600 | 0.806 |
| 57.800 | 0.823 |
| 60.100 | 0.832 |
| 61.700 | 0.869 |
| 64.100 | 0.954 |
| 66.900 | 0.952 |
| 68.800 | 0.860 |
| 70.300 | 0.822 |
| 72.700 | 0.779 |
| 74.200 | 0.736 |
| 76.500 | 0.716 |
| 77.300 | 0.747 |
| 80.200 | 0.776 |
| 81.600 | 0.808 |
| 83.500 | 0.815 |
| 85.100 | 0.847 |
| 86.500 | 0.874 |
| 87.900 | 0.920 |
| 90.000 | 0.973 |
| 92.500 | 0.998 |
| 96.190 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table A.2. AFACT values for the B-1/shroud 1 COBRA-IV model based on the minimum restriction definition

| AXL[a] | VALUE OF I IS: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.993 | 0.989 | 0.989 | 0.989 | 0.993 | 0.984 | 0.973 | 0.973 | 0.973 | 0.984 |
| 1.800 | 0.964 | 0.944 | 0.944 | 0.944 | 0.964 | 0.923 | 0.867 | 0.867 | 0.867 | 0.923 |
| 3.300 | 0.937 | 0.903 | 0.903 | 0.903 | 0.937 | 0.867 | 0.770 | 0.770 | 0.770 | 0.867 |
| 5.200 | 0.936 | 0.902 | 0.902 | 0.902 | 0.936 | 0.865 | 0.767 | 0.767 | 0.767 | 0.865 |
| 8.900 | 0.977 | 0.965 | 0.965 | 0.965 | 0.977 | 0.952 | 0.917 | 0.917 | 0.917 | 0.952 |
| 11.800 | 0.974 | 0.960 | 0.960 | 0.960 | 0.974 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 |
| 14.100 | 0.913 | 0.866 | 0.866 | 0.866 | 0.913 | 0.817 | 0.683 | 0.683 | 0.683 | 0.817 |
| 15.400 | 0.900 | 0.846 | 0.846 | 0.846 | 0.900 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 |
| 17.300 | 0.899 | 0.844 | 0.844 | 0.844 | 0.899 | 0.787 | 0.631 | 0.631 | 0.631 | 0.787 |
| 18.800 | 0.884 | 0.822 | 0.822 | 0.822 | 0.884 | 0.756 | 0.577 | 0.577 | 0.577 | 0.756 |
| 20.100 | 0.880 | 0.815 | 0.815 | 0.815 | 0.880 | 0.747 | 0.562 | 0.562 | 0.562 | 0.747 |
| 20.600 | 0.884 | 0.821 | 0.821 | 0.821 | 0.884 | 0.755 | 0.576 | 0.576 | 0.576 | 0.755 |
| 22.300 | 0.883 | 0.820 | 0.820 | 0.820 | 0.883 | 0.754 | 0.574 | 0.574 | 0.574 | 0.754 |
| 23.900 | 0.876 | 0.810 | 0.810 | 0.810 | 0.876 | 0.739 | 0.549 | 0.549 | 0.549 | 0.739 |
| 25.500 | 0.878 | 0.813 | 0.813 | 0.813 | 0.878 | 0.743 | 0.556 | 0.556 | 0.556 | 0.743 |
| 26.500 | 0.876 | 0.809 | 0.809 | 0.809 | 0.876 | 0.738 | 0.546 | 0.546 | 0.546 | 0.738 |
| 28.100 | 0.879 | 0.813 | 0.813 | 0.813 | 0.879 | 0.744 | 0.557 | 0.557 | 0.557 | 0.744 |
| 29.700 | 0.892 | 0.834 | 0.834 | 0.834 | 0.892 | 0.773 | 0.607 | 0.607 | 0.607 | 0.773 |
| 30.700 | 0.899 | 0.845 | 0.845 | 0.845 | 0.899 | 0.787 | 0.632 | 0.632 | 0.632 | 0.787 |
| 33.200 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 | 0.808 | 0.668 | 0.668 | 0.668 | 0.808 |
| 34.500 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 | 0.808 | 0.667 | 0.667 | 0.667 | 0.808 |
| 36.600 | 0.910 | 0.862 | 0.862 | 0.862 | 0.910 | 0.810 | 0.672 | 0.672 | 0.672 | 0.810 |
| 38.100 | 0.905 | 0.854 | 0.854 | 0.854 | 0.905 | 0.801 | 0.655 | 0.655 | 0.655 | 0.801 |
| 39.700 | 0.914 | 0.825 | 0.825 | 0.825 | 0.886 | 0.815 | 0.585 | 0.585 | 0.585 | 0.760 |
| 40.800 | 0.910 | 0.818 | 0.818 | 0.818 | 0.882 | 0.808 | 0.568 | 0.568 | 0.568 | 0.750 |
| 42.900 | 0.887 | 0.827 | 0.827 | 0.827 | 0.887 | 0.762 | 0.589 | 0.589 | 0.589 | 0.762 |
| 44.700 | 0.919 | 0.803 | 0.803 | 0.803 | 0.872 | 0.840 | 0.534 | 0.534 | 0.534 | 0.731 |
| 46.700 | 0.915 | 0.794 | 0.794 | 0.794 | 0.866 | 0.832 | 0.511 | 0.511 | 0.511 | 0.717 |
| 47.500 | 0.915 | 0.795 | 0.795 | 0.795 | 0.867 | 0.833 | 0.513 | 0.513 | 0.513 | 0.719 |
| 48.600 | 0.878 | 0.812 | 0.812 | 0.812 | 0.878 | 0.743 | 0.555 | 0.555 | 0.555 | 0.743 |
| 50.400 | 0.885 | 0.822 | 0.822 | 0.822 | 0.885 | 0.757 | 0.579 | 0.579 | 0.579 | 0.757 |
| 52.400 | 0.896 | 0.840 | 0.840 | 0.840 | 0.896 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 |
| 54.000 | 0.907 | 0.857 | 0.857 | 0.857 | 0.907 | 0.804 | 0.660 | 0.660 | 0.660 | 0.804 |
| 55.600 | 0.917 | 0.873 | 0.873 | 0.873 | 0.917 | 0.825 | 0.698 | 0.698 | 0.698 | 0.825 |
| 57.800 | 0.924 | 0.884 | 0.884 | 0.884 | 0.924 | 0.841 | 0.724 | 0.724 | 0.724 | 0.841 |
| 60.100 | 0.928 | 0.889 | 0.889 | 0.889 | 0.928 | 0.849 | 0.738 | 0.738 | 0.738 | 0.849 |
| 61.700 | 0.944 | 0.914 | 0.914 | 0.914 | 0.944 | 0.882 | 0.795 | 0.795 | 0.795 | 0.882 |
| 64.100 | 0.980 | 0.970 | 0.970 | 0.970 | 0.980 | 0.958 | 0.928 | 0.928 | 0.928 | 0.958 |
| 66.900 | 0.979 | 0.968 | 0.968 | 0.968 | 0.979 | 0.957 | 0.925 | 0.925 | 0.925 | 0.957 |
| 68.800 | 0.940 | 0.908 | 0.908 | 0.908 | 0.940 | 0.874 | 0.782 | 0.782 | 0.782 | 0.874 |
| 70.300 | 0.924 | 0.883 | 0.883 | 0.883 | 0.924 | 0.840 | 0.723 | 0.723 | 0.723 | 0.840 |
| 72.700 | 0.906 | 0.855 | 0.855 | 0.855 | 0.906 | 0.801 | 0.656 | 0.656 | 0.656 | 0.801 |
| 74.200 | 0.887 | 0.826 | 0.826 | 0.826 | 0.926 | 0.762 | 0.588 | 0.588 | 0.588 | 0.854 |
| 76.500 | 0.879 | 0.813 | 0.813 | 0.813 | 0.920 | 0.744 | 0.557 | 0.557 | 0.557 | 0.843 |
| 77.300 | 0.892 | 0.834 | 0.834 | 0.834 | 0.929 | 0.772 | 0.606 | 0.606 | 0.606 | 0.860 |
| 80.200 | 0.904 | 0.852 | 0.852 | 0.852 | 0.904 | 0.798 | 0.650 | 0.650 | 0.650 | 0.798 |
| 81.600 | 0.918 | 0.874 | 0.874 | 0.874 | 0.918 | 0.827 | 0.701 | 0.701 | 0.701 | 0.827 |
| 83.500 | 0.921 | 0.879 | 0.879 | 0.879 | 0.921 | 0.834 | 0.712 | 0.712 | 0.712 | 0.834 |
| 85.100 | 0.935 | 0.900 | 0.900 | 0.900 | 0.935 | 0.862 | 0.762 | 0.762 | 0.762 | 0.862 |
| 86.500 | 0.946 | 0.917 | 0.917 | 0.917 | 0.946 | 0.886 | 0.803 | 0.803 | 0.803 | 0.886 |
| 87.900 | 0.966 | 0.948 | 0.948 | 0.948 | 0.966 | 0.928 | 0.876 | 0.876 | 0.876 | 0.928 |
| 90.000 | 0.988 | 0.982 | 0.982 | 0.982 | 0.988 | 0.976 | 0.958 | 0.958 | 0.958 | 0.976 |
| 92.500 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.998 | 0.997 | 0.997 | 0.997 | 0.998 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table A.2 (continued)

| AXL[a] | VALUE OF I IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.984 | 0.973 | 0.973 | 0.973 | 0.984 | 0.984 | 0.973 | 0.973 | 0.973 | 0.984 |
| 1.800 | 0.923 | 0.867 | 0.867 | 0.867 | 0.923 | 0.923 | 0.867 | 0.867 | 0.867 | 0.923 |
| 3.300 | 0.867 | 0.770 | 0.770 | 0.770 | 0.867 | 0.867 | 0.770 | 0.770 | 0.770 | 0.867 |
| 5.200 | 0.865 | 0.767 | 0.767 | 0.767 | 0.865 | 0.865 | 0.767 | 0.767 | 0.767 | 0.865 |
| 8.900 | 0.952 | 0.917 | 0.917 | 0.917 | 0.952 | 0.952 | 0.917 | 0.917 | 0.917 | 0.952 |
| 11.800 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 |
| 14.100 | 0.817 | 0.683 | 0.683 | 0.683 | 0.817 | 0.817 | 0.683 | 0.683 | 0.683 | 0.817 |
| 15.400 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 |
| 17.300 | 0.787 | 0.631 | 0.631 | 0.631 | 0.787 | 0.787 | 0.631 | 0.631 | 0.631 | 0.787 |
| 18.800 | 0.756 | 0.577 | 0.577 | 0.577 | 0.756 | 0.756 | 0.577 | 0.577 | 0.577 | 0.756 |
| 20.100 | 0.747 | 0.562 | 0.562 | 0.562 | 0.747 | 0.747 | 0.562 | 0.562 | 0.562 | 0.747 |
| 20.600 | 0.755 | 0.576 | 0.576 | 0.576 | 0.755 | 0.755 | 0.576 | 0.576 | 0.576 | 0.755 |
| 22.300 | 0.754 | 0.574 | 0.574 | 0.574 | 0.754 | 0.754 | 0.574 | 0.574 | 0.574 | 0.754 |
| 23.900 | 0.739 | 0.549 | 0.549 | 0.549 | 0.739 | 0.739 | 0.549 | 0.549 | 0.549 | 0.739 |
| 25.500 | 0.743 | 0.556 | 0.556 | 0.556 | 0.743 | 0.743 | 0.556 | 0.556 | 0.556 | 0.743 |
| 26.500 | 0.738 | 0.546 | 0.546 | 0.546 | 0.738 | 0.738 | 0.546 | 0.546 | 0.546 | 0.738 |
| 28.100 | 0.744 | 0.557 | 0.557 | 0.557 | 0.744 | 0.744 | 0.557 | 0.557 | 0.557 | 0.744 |
| 29.700 | 0.773 | 0.607 | 0.607 | 0.607 | 0.773 | 0.773 | 0.607 | 0.607 | 0.607 | 0.773 |
| 30.700 | 0.787 | 0.632 | 0.632 | 0.632 | 0.787 | 0.787 | 0.632 | 0.632 | 0.632 | 0.787 |
| 33.200 | 0.808 | 0.668 | 0.668 | 0.668 | 0.808 | 0.808 | 0.668 | 0.668 | 0.668 | 0.808 |
| 34.500 | 0.808 | 0.667 | 0.667 | 0.667 | 0.808 | 0.808 | 0.667 | 0.667 | 0.667 | 0.808 |
| 36.600 | 0.810 | 0.672 | 0.672 | 0.672 | 0.810 | 0.810 | 0.672 | 0.672 | 0.672 | 0.810 |
| 38.100 | 0.801 | 0.655 | 0.655 | 0.655 | 0.801 | 0.801 | 0.655 | 0.655 | 0.655 | 0.801 |
| 39.700 | 0.760 | 0.585 | 0.585 | 0.585 | 0.760 | 0.760 | 0.585 | 0.585 | 0.585 | 0.760 |
| 40.800 | 0.750 | 0.568 | 0.568 | 0.568 | 0.750 | 0.750 | 0.568 | 0.568 | 0.568 | 0.750 |
| 42.900 | 0.762 | 0.589 | 0.589 | 0.589 | 0.762 | 0.762 | 0.589 | 0.589 | 0.589 | 0.762 |
| 44.700 | 0.791 | 0.534 | 0.534 | 0.534 | 0.731 | 0.731 | 0.534 | 0.534 | 0.534 | 0.731 |
| 46.700 | 0.780 | 0.511 | 0.511 | 0.511 | 0.717 | 0.717 | 0.511 | 0.511 | 0.511 | 0.717 |
| 47.500 | 0.781 | 0.513 | 0.513 | 0.513 | 0.719 | 0.719 | 0.513 | 0.513 | 0.513 | 0.719 |
| 48.600 | 0.743 | 0.555 | 0.555 | 0.555 | 0.743 | 0.743 | 0.555 | 0.555 | 0.555 | 0.743 |
| 50.400 | 0.757 | 0.579 | 0.579 | 0.579 | 0.757 | 0.757 | 0.579 | 0.579 | 0.579 | 0.757 |
| 52.400 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 |
| 54.000 | 0.804 | 0.660 | 0.660 | 0.660 | 0.804 | 0.804 | 0.660 | 0.660 | 0.660 | 0.804 |
| 55.600 | 0.825 | 0.698 | 0.698 | 0.698 | 0.825 | 0.825 | 0.698 | 0.698 | 0.698 | 0.825 |
| 57.800 | 0.841 | 0.724 | 0.724 | 0.724 | 0.841 | 0.841 | 0.724 | 0.724 | 0.724 | 0.841 |
| 60.100 | 0.849 | 0.738 | 0.738 | 0.738 | 0.849 | 0.849 | 0.738 | 0.738 | 0.738 | 0.849 |
| 61.700 | 0.882 | 0.795 | 0.795 | 0.795 | 0.882 | 0.882 | 0.795 | 0.795 | 0.795 | 0.882 |
| 64.100 | 0.958 | 0.928 | 0.928 | 0.928 | 0.958 | 0.958 | 0.928 | 0.928 | 0.928 | 0.958 |
| 66.900 | 0.957 | 0.925 | 0.925 | 0.925 | 0.957 | 0.957 | 0.925 | 0.925 | 0.925 | 0.957 |
| 68.800 | 0.874 | 0.782 | 0.782 | 0.782 | 0.874 | 0.874 | 0.782 | 0.782 | 0.782 | 0.874 |
| 70.300 | 0.840 | 0.723 | 0.723 | 0.723 | 0.840 | 0.840 | 0.723 | 0.723 | 0.723 | 0.840 |
| 72.700 | 0.801 | 0.656 | 0.656 | 0.656 | 0.801 | 0.801 | 0.656 | 0.656 | 0.656 | 0.801 |
| 74.200 | 0.762 | 0.588 | 0.588 | 0.588 | 0.854 | 0.762 | 0.588 | 0.588 | 0.588 | 0.854 |
| 76.500 | 0.744 | 0.557 | 0.557 | 0.557 | 0.843 | 0.744 | 0.557 | 0.557 | 0.557 | 0.843 |
| 77.300 | 0.772 | 0.606 | 0.606 | 0.606 | 0.860 | 0.772 | 0.606 | 0.606 | 0.606 | 0.860 |
| 80.200 | 0.798 | 0.650 | 0.650 | 0.650 | 0.798 | 0.798 | 0.650 | 0.650 | 0.650 | 0.798 |
| 81.600 | 0.827 | 0.701 | 0.701 | 0.701 | 0.827 | 0.827 | 0.701 | 0.701 | 0.701 | 0.827 |
| 83.500 | 0.834 | 0.712 | 0.712 | 0.712 | 0.834 | 0.834 | 0.712 | 0.712 | 0.712 | 0.834 |
| 85.100 | 0.862 | 0.762 | 0.762 | 0.762 | 0.862 | 0.862 | 0.762 | 0.762 | 0.762 | 0.862 |
| 86.500 | 0.886 | 0.803 | 0.803 | 0.803 | 0.886 | 0.886 | 0.803 | 0.803 | 0.803 | 0.886 |
| 87.900 | 0.928 | 0.876 | 0.876 | 0.876 | 0.928 | 0.928 | 0.876 | 0.876 | 0.876 | 0.928 |
| 90.000 | 0.976 | 0.958 | 0.958 | 0.958 | 0.976 | 0.976 | 0.958 | 0.958 | 0.958 | 0.976 |
| 92.500 | 0.998 | 0.997 | 0.997 | 0.997 | 0.998 | 0.998 | 0.997 | 0.997 | 0.997 | 0.998 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table A.2 (continued)

| AXL[a] | VALUE OF I IS: 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.993 | 0.989 | 0.989 | 0.989 | 0.993 |
| 1.800 | 0.964 | 0.944 | 0.944 | 0.944 | 0.964 |
| 3.300 | 0.937 | 0.903 | 0.903 | 0.903 | 0.937 |
| 5.200 | 0.936 | 0.902 | 0.902 | 0.902 | 0.936 |
| 8.900 | 0.977 | 0.965 | 0.965 | 0.965 | 0.977 |
| 11.800 | 0.974 | 0.960 | 0.960 | 0.960 | 0.974 |
| 14.100 | 0.913 | 0.866 | 0.866 | 0.866 | 0.913 |
| 15.400 | 0.900 | 0.846 | 0.846 | 0.846 | 0.900 |
| 17.300 | 0.899 | 0.844 | 0.844 | 0.844 | 0.899 |
| 18.800 | 0.884 | 0.822 | 0.822 | 0.822 | 0.884 |
| 20.100 | 0.880 | 0.815 | 0.815 | 0.815 | 0.880 |
| 20.600 | 0.884 | 0.821 | 0.821 | 0.821 | 0.884 |
| 22.300 | 0.883 | 0.820 | 0.820 | 0.820 | 0.883 |
| 23.900 | 0.876 | 0.810 | 0.810 | 0.810 | 0.876 |
| 25.500 | 0.878 | 0.813 | 0.813 | 0.813 | 0.878 |
| 26.500 | 0.876 | 0.809 | 0.809 | 0.809 | 0.876 |
| 28.100 | 0.879 | 0.813 | 0.813 | 0.913 | 0.879 |
| 29.700 | 0.892 | 0.834 | 0.834 | 0.834 | 0.892 |
| 30.700 | 0.899 | 0.845 | 0.845 | 0.845 | 0.899 |
| 33.200 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 |
| 34.500 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 |
| 36.600 | 0.910 | 0.862 | 0.862 | 0.862 | 0.910 |
| 38.100 | 0.905 | 0.854 | 0.854 | 0.854 | 0.905 |
| 39.700 | 0.886 | 0.825 | 0.825 | 0.825 | 0.886 |
| 40.800 | 0.882 | 0.818 | 0.818 | 0.818 | 0.882 |
| 42.900 | 0.887 | 0.827 | 0.827 | 0.827 | 0.887 |
| 44.700 | 0.872 | 0.803 | 0.803 | 0.803 | 0.872 |
| 46.700 | 0.866 | 0.794 | 0.794 | 0.794 | 0.866 |
| 47.500 | 0.867 | 0.795 | 0.795 | 0.795 | 0.867 |
| 48.600 | 0.878 | 0.812 | 0.812 | 0.812 | 0.878 |
| 50.400 | 0.885 | 0.822 | 0.822 | 0.822 | 0.885 |
| 52.400 | 0.896 | 0.840 | 0.840 | 0.840 | 0.896 |
| 54.000 | 0.907 | 0.857 | 0.857 | 0.857 | 0.907 |
| 55.600 | 0.917 | 0.873 | 0.873 | 0.873 | 0.917 |
| 57.800 | 0.924 | 0.884 | 0.884 | 0.884 | 0.924 |
| 60.100 | 0.928 | 0.889 | 0.889 | 0.889 | 0.928 |
| 61.700 | 0.944 | 0.914 | 0.914 | 0.914 | 0.944 |
| 64.100 | 0.980 | 0.970 | 0.970 | 0.970 | 0.980 |
| 66.900 | 0.979 | 0.968 | 0.968 | 0.968 | 0.979 |
| 68.800 | 0.940 | 0.908 | 0.908 | 0.908 | 0.940 |
| 70.300 | 0.924 | 0.883 | 0.883 | 0.883 | 0.924 |
| 72.700 | 0.906 | 0.855 | 0.855 | 0.855 | 0.906 |
| 74.200 | 0.887 | 0.826 | 0.826 | 0.826 | 0.887 |
| 76.500 | 0.879 | 0.813 | 0.813 | 0.813 | 0.879 |
| 77.300 | 0.892 | 0.834 | 0.834 | 0.834 | 0.892 |
| 80.200 | 0.904 | 0.852 | 0.852 | 0.852 | 0.904 |
| 81.600 | 0.918 | 0.874 | 0.874 | 0.874 | 0.918 |
| 83.500 | 0.921 | 0.879 | 0.879 | 0.879 | 0.921 |
| 85.100 | 0.935 | 0.900 | 0.900 | 0.900 | 0.935 |
| 86.500 | 0.946 | 0.917 | 0.917 | 0.917 | 0.946 |
| 87.900 | 0.966 | 0.948 | 0.948 | 0.948 | 0.966 |
| 90.000 | 0.988 | 0.982 | 0.982 | 0.982 | 0.988 |
| 92.500 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table A.3. GFACT values for the B-1/shroud 1 COBRA-IV model based on the minimum restriction definition

| GAPXL[a] | VALUE OF K IS: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.988 | 0.981 | 0.988 | 0.949 | 0.988 | 0.949 | 0.988 | 0.949 | 0.981 | 0.981 |
| 1.800 | 0.941 | 0.908 | 0.941 | 0.756 | 0.941 | 0.756 | 0.941 | 0.756 | 0.908 | 0.908 |
| 3.300 | 0.900 | 0.845 | 0.900 | 0.589 | 0.900 | 0.589 | 0.900 | 0.589 | 0.845 | 0.845 |
| 5.200 | 0.899 | 0.843 | 0.899 | 0.584 | 0.899 | 0.584 | 0.899 | 0.584 | 0.843 | 0.843 |
| 8.900 | 0.962 | 0.942 | 0.962 | 0.846 | 0.962 | 0.846 | 0.962 | 0.846 | 0.942 | 0.942 |
| 11.800 | 0.958 | 0.934 | 0.958 | 0.826 | 0.958 | 0.826 | 0.958 | 0.826 | 0.934 | 0.934 |
| 14.100 | 0.865 | 0.791 | 0.865 | 0.446 | 0.865 | 0.446 | 0.865 | 0.446 | 0.791 | 0.791 |
| 15.400 | 0.846 | 0.762 | 0.846 | 0.369 | 0.846 | 0.369 | 0.846 | 0.369 | 0.762 | 0.762 |
| 17.300 | 0.845 | 0.760 | 0.845 | 0.363 | 0.845 | 0.363 | 0.845 | 0.363 | 0.760 | 0.760 |
| 18.800 | 0.824 | 0.728 | 0.824 | 0.278 | 0.824 | 0.278 | 0.824 | 0.278 | 0.728 | 0.728 |
| 20.100 | 0.818 | 0.719 | 0.818 | 0.255 | 0.818 | 0.255 | 0.818 | 0.255 | 0.719 | 0.719 |
| 20.600 | 0.824 | 0.727 | 0.824 | 0.277 | 0.824 | 0.277 | 0.824 | 0.277 | 0.727 | 0.727 |
| 22.300 | 0.823 | 0.726 | 0.823 | 0.274 | 0.823 | 0.274 | 0.823 | 0.274 | 0.726 | 0.726 |
| 23.900 | 0.814 | 0.712 | 0.814 | 0.235 | 0.814 | 0.235 | 0.814 | 0.235 | 0.712 | 0.712 |
| 25.500 | 0.816 | 0.716 | 0.816 | 0.246 | 0.816 | 0.246 | 0.816 | 0.246 | 0.716 | 0.716 |
| 26.500 | 0.812 | 0.710 | 0.812 | 0.231 | 0.812 | 0.231 | 0.812 | 0.231 | 0.710 | 0.710 |
| 28.100 | 0.817 | 0.716 | 0.817 | 0.248 | 0.817 | 0.248 | 0.817 | 0.248 | 0.716 | 0.716 |
| 29.700 | 0.835 | 0.746 | 0.835 | 0.325 | 0.835 | 0.325 | 0.835 | 0.325 | 0.746 | 0.746 |
| 30.700 | 0.845 | 0.760 | 0.845 | 0.364 | 0.845 | 0.364 | 0.845 | 0.364 | 0.760 | 0.760 |
| 33.200 | 0.859 | 0.782 | 0.859 | 0.422 | 0.859 | 0.422 | 0.859 | 0.422 | 0.782 | 0.782 |
| 34.500 | 0.859 | 0.781 | 0.859 | 0.420 | 0.859 | 0.420 | 0.859 | 0.420 | 0.781 | 0.781 |
| 36.600 | 0.861 | 0.784 | 0.861 | 0.428 | 0.861 | 0.428 | 0.861 | 0.428 | 0.784 | 0.784 |
| 38.100 | 0.854 | 0.774 | 0.854 | 0.401 | 0.854 | 0.401 | 0.854 | 0.401 | 0.774 | 0.774 |
| 39.700 | 0.827 | 0.733 | 0.827 | 0.291 | 0.827 | 0.291 | 0.827 | 0.291 | 0.733 | 0.733 |
| 40.800 | 0.821 | 0.723 | 0.821 | 0.265 | 0.821 | 0.265 | 0.821 | 0.265 | 0.723 | 0.723 |
| 42.900 | 0.829 | 0.735 | 0.829 | 0.297 | 0.829 | 0.297 | 0.829 | 0.297 | 0.735 | 0.735 |
| 44.700 | 0.808 | 0.703 | 0.808 | 0.213 | 0.808 | 0.213 | 0.808 | 0.213 | 0.703 | 0.703 |
| 46.700 | 0.800 | 0.690 | 0.800 | 0.178 | 0.800 | 0.178 | 0.800 | 0.178 | 0.690 | 0.690 |
| 47.500 | 0.800 | 0.691 | 0.800 | 0.181 | 0.800 | 0.181 | 0.800 | 0.181 | 0.691 | 0.691 |
| 48.600 | 0.816 | 0.715 | 0.816 | 0.245 | 0.816 | 0.245 | 0.816 | 0.245 | 0.715 | 0.715 |
| 50.400 | 0.825 | 0.729 | 0.825 | 0.282 | 0.825 | 0.282 | 0.825 | 0.282 | 0.729 | 0.729 |
| 52.400 | 0.840 | 0.753 | 0.840 | 0.346 | 0.840 | 0.346 | 0.840 | 0.346 | 0.753 | 0.753 |
| 54.000 | 0.856 | 0.777 | 0.856 | 0.409 | 0.856 | 0.409 | 0.856 | 0.409 | 0.777 | 0.777 |
| 55.600 | 0.871 | 0.800 | 0.871 | 0.470 | 0.871 | 0.470 | 0.871 | 0.470 | 0.800 | 0.800 |
| 57.800 | 0.881 | 0.816 | 0.881 | 0.513 | 0.881 | 0.513 | 0.881 | 0.513 | 0.816 | 0.816 |
| 60.100 | 0.887 | 0.825 | 0.887 | 0.536 | 0.887 | 0.536 | 0.887 | 0.536 | 0.825 | 0.825 |
| 61.700 | 0.910 | 0.861 | 0.910 | 0.632 | 0.910 | 0.632 | 0.910 | 0.632 | 0.861 | 0.861 |
| 64.100 | 0.967 | 0.949 | 0.967 | 0.866 | 0.967 | 0.866 | 0.967 | 0.866 | 0.949 | 0.949 |
| 66.900 | 0.966 | 0.947 | 0.966 | 0.860 | 0.966 | 0.860 | 0.966 | 0.860 | 0.947 | 0.947 |
| 68.800 | 0.905 | 0.853 | 0.905 | 0.610 | 0.905 | 0.610 | 0.905 | 0.610 | 0.853 | 0.853 |
| 70.300 | 0.881 | 0.816 | 0.881 | 0.511 | 0.881 | 0.511 | 0.881 | 0.511 | 0.816 | 0.816 |
| 72.700 | 0.854 | 0.775 | 0.854 | 0.403 | 0.854 | 0.403 | 0.854 | 0.403 | 0.775 | 0.775 |
| 74.200 | 0.828 | 0.734 | 0.828 | 0.296 | 0.828 | 0.296 | 0.828 | 0.296 | 0.734 | 0.734 |
| 76.500 | 0.817 | 0.716 | 0.817 | 0.248 | 0.817 | 0.248 | 0.817 | 0.248 | 0.716 | 0.716 |
| 77.300 | 0.835 | 0.745 | 0.835 | 0.324 | 0.835 | 0.324 | 0.835 | 0.324 | 0.745 | 0.745 |
| 80.200 | 0.852 | 0.771 | 0.852 | 0.393 | 0.852 | 0.393 | 0.852 | 0.393 | 0.771 | 0.771 |
| 81.600 | 0.872 | 0.802 | 0.872 | 0.475 | 0.872 | 0.475 | 0.872 | 0.475 | 0.802 | 0.802 |
| 83.500 | 0.876 | 0.809 | 0.876 | 0.493 | 0.876 | 0.493 | 0.876 | 0.493 | 0.809 | 0.809 |
| 85.100 | 0.897 | 0.840 | 0.897 | 0.576 | 0.897 | 0.576 | 0.897 | 0.576 | 0.840 | 0.840 |
| 86.500 | 0.914 | 0.866 | 0.914 | 0.645 | 0.914 | 0.645 | 0.914 | 0.645 | 0.866 | 0.866 |
| 87.900 | 0.944 | 0.914 | 0.944 | 0.772 | 0.944 | 0.772 | 0.944 | 0.772 | 0.914 | 0.914 |
| 90.000 | 0.981 | 0.970 | 0.981 | 0.921 | 0.981 | 0.921 | 0.981 | 0.921 | 0.970 | 0.970 |
| 92.500 | 0.999 | 0.998 | 0.999 | 0.994 | 0.999 | 0.994 | 0.999 | 0.994 | 0.998 | 0.998 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table A.3 (continued)

| GAPXL[a] | VALUE OF K IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.981 | 0.981 | 0.949 |
| 1.800 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.908 | 0.908 | 0.756 |
| 3.300 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.845 | 0.845 | 0.589 |
| 5.200 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.843 | 0.843 | 0.584 |
| 8.900 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.942 | 0.942 | 0.846 |
| 11.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.934 | 0.826 |
| 14.100 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.791 | 0.791 | 0.446 |
| 15.400 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.762 | 0.369 |
| 17.300 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.760 | 0.760 | 0.363 |
| 18.800 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.728 | 0.728 | 0.278 |
| 20.100 | 0.255 | 0.255 | 0.255 | 0.255 | 0.255 | 0.255 | 0.255 | 0.719 | 0.719 | 0.255 |
| 20.600 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.727 | 0.727 | 0.277 |
| 22.300 | 0.274 | 0.274 | 0.274 | 0.274 | 0.274 | 0.274 | 0.274 | 0.726 | 0.726 | 0.274 |
| 23.900 | 0.235 | 0.235 | 0.235 | 0.235 | 0.235 | 0.235 | 0.235 | 0.712 | 0.712 | 0.235 |
| 25.500 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.716 | 0.716 | 0.246 |
| 26.500 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.710 | 0.710 | 0.231 |
| 28.100 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.716 | 0.716 | 0.248 |
| 29.700 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.746 | 0.746 | 0.325 |
| 30.700 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.760 | 0.760 | 0.364 |
| 33.200 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.782 | 0.782 | 0.422 |
| 34.500 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.781 | 0.781 | 0.420 |
| 36.600 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.784 | 0.784 | 0.428 |
| 38.100 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.774 | 0.774 | 0.401 |
| 39.700 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.733 | 0.733 | 0.291 |
| 40.800 | 0.265 | 0.265 | 0.265 | 0.265 | 0.265 | 0.265 | 0.265 | 0.723 | 0.723 | 0.265 |
| 42.900 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.735 | 0.735 | 0.297 |
| 44.700 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.703 | 0.703 | 0.213 |
| 46.700 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.690 | 0.690 | 0.178 |
| 47.500 | 0.181 | 0.181 | 0.181 | 0.181 | 0.181 | 0.181 | 0.181 | 0.691 | 0.691 | 0.181 |
| 48.600 | 0.245 | 0.245 | 0.245 | 0.245 | 0.245 | 0.245 | 0.245 | 0.715 | 0.715 | 0.245 |
| 50.400 | 0.282 | 0.282 | 0.282 | 0.282 | 0.282 | 0.282 | 0.282 | 0.729 | 0.729 | 0.282 |
| 52.400 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.753 | 0.346 |
| 54.000 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.777 | 0.777 | 0.409 |
| 55.600 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.800 | 0.800 | 0.470 |
| 57.800 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.816 | 0.816 | 0.513 |
| 60.100 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.825 | 0.825 | 0.536 |
| 61.700 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.861 | 0.861 | 0.632 |
| 64.100 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.949 | 0.949 | 0.866 |
| 66.900 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.947 | 0.947 | 0.860 |
| 68.800 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.853 | 0.853 | 0.610 |
| 70.300 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.816 | 0.816 | 0.511 |
| 72.700 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.775 | 0.403 |
| 74.200 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.734 | 0.296 |
| 76.500 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.716 | 0.716 | 0.248 |
| 77.300 | 0.324 | 0.324 | 0.324 | 0.324 | 0.324 | 0.324 | 0.324 | 0.745 | 0.745 | 0.324 |
| 80.200 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.771 | 0.771 | 0.393 |
| 81.600 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.802 | 0.802 | 0.475 |
| 83.500 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.809 | 0.809 | 0.493 |
| 85.100 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.840 | 0.840 | 0.576 |
| 86.500 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.866 | 0.866 | 0.645 |
| 87.900 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.914 | 0.914 | 0.772 |
| 90.000 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.970 | 0.970 | 0.921 |
| 92.500 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.998 | 0.998 | 0.994 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table A.3 (continued)

| GAPXL[a] | VALUE OF K IS: 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.981 | 0.981 | 0.949 | 0.949 |
| 1.800 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.908 | 0.908 | 0.756 | 0.756 |
| 3.300 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.845 | 0.845 | 0.589 | 0.589 |
| 5.200 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.843 | 0.843 | 0.584 | 0.584 |
| 8.900 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.942 | 0.942 | 0.846 | 0.846 |
| 11.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.934 | 0.826 | 0.826 |
| 14.100 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.791 | 0.791 | 0.446 | 0.446 |
| 15.400 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.762 | 0.369 | 0.369 |
| 17.300 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.760 | 0.760 | 0.363 | 0.363 |
| 18.800 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.728 | 0.728 | 0.278 | 0.278 |
| 20.100 | 0.255 | 0.255 | 0.255 | 0.255 | 0.255 | 0.255 | 0.719 | 0.719 | 0.255 | 0.255 |
| 20.600 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.727 | 0.727 | 0.277 | 0.277 |
| 22.300 | 0.274 | 0.274 | 0.274 | 0.274 | 0.274 | 0.274 | 0.726 | 0.726 | 0.274 | 0.274 |
| 23.900 | 0.235 | 0.235 | 0.235 | 0.235 | 0.235 | 0.235 | 0.712 | 0.712 | 0.235 | 0.235 |
| 25.500 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.716 | 0.716 | 0.246 | 0.246 |
| 26.500 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.710 | 0.710 | 0.231 | 0.231 |
| 28.100 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.716 | 0.716 | 0.248 | 0.248 |
| 29.700 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.746 | 0.746 | 0.325 | 0.325 |
| 30.700 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.760 | 0.760 | 0.364 | 0.364 |
| 33.200 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.782 | 0.782 | 0.422 | 0.422 |
| 34.500 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.781 | 0.781 | 0.420 | 0.420 |
| 36.600 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.784 | 0.784 | 0.428 | 0.428 |
| 38.100 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.774 | 0.774 | 0.401 | 0.401 |
| 39.700 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.733 | 0.733 | 0.291 | 0.291 |
| 40.800 | 0.265 | 0.265 | 0.265 | 0.265 | 0.265 | 0.265 | 0.723 | 0.723 | 0.265 | 0.265 |
| 42.900 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.735 | 0.735 | 0.297 | 0.297 |
| 44.700 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.703 | 0.703 | 0.213 | 0.213 |
| 46.700 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.690 | 0.690 | 0.178 | 0.178 |
| 47.500 | 0.181 | 0.181 | 0.181 | 0.181 | 0.181 | 0.181 | 0.691 | 0.691 | 0.181 | 0.181 |
| 48.600 | 0.245 | 0.245 | 0.245 | 0.245 | 0.245 | 0.245 | 0.715 | 0.715 | 0.245 | 0.245 |
| 50.400 | 0.282 | 0.282 | 0.282 | 0.282 | 0.282 | 0.282 | 0.729 | 0.729 | 0.282 | 0.282 |
| 52.400 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.753 | 0.346 | 0.346 |
| 54.000 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.777 | 0.777 | 0.409 | 0.409 |
| 55.600 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.800 | 0.800 | 0.470 | 0.470 |
| 57.800 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.816 | 0.816 | 0.513 | 0.513 |
| 60.100 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.825 | 0.825 | 0.536 | 0.536 |
| 61.700 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.861 | 0.861 | 0.632 | 0.632 |
| 64.100 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.949 | 0.949 | 0.866 | 0.866 |
| 66.900 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.947 | 0.947 | 0.860 | 0.860 |
| 68.800 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.853 | 0.853 | 0.610 | 0.610 |
| 70.300 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.816 | 0.816 | 0.511 | 0.511 |
| 72.700 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.775 | 0.403 | 0.403 |
| 74.200 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.734 | 0.296 | 0.296 |
| 76.500 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.716 | 0.716 | 0.248 | 0.248 |
| 77.300 | 0.324 | 0.324 | 0.324 | 0.324 | 0.324 | 0.324 | 0.745 | 0.745 | 0.324 | 0.324 |
| 80.200 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.771 | 0.771 | 0.393 | 0.393 |
| 81.600 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.802 | 0.802 | 0.475 | 0.475 |
| 83.500 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.809 | 0.809 | 0.493 | 0.493 |
| 85.100 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.840 | 0.840 | 0.576 | 0.576 |
| 86.500 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.866 | 0.866 | 0.645 | 0.645 |
| 87.900 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.914 | 0.914 | 0.772 | 0.772 |
| 90.000 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.970 | 0.970 | 0.921 | 0.921 |
| 92.500 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.998 | 0.998 | 0.994 | 0.994 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table A.3 (continued)

| GAPXL[a] | VALUE OF K IS: 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.981 | 0.988 | 0.988 | 0.988 | 0.988 |
| 1.800 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.908 | 0.941 | 0.941 | 0.941 | 0.941 |
| 3.300 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.845 | 0.900 | 0.900 | 0.900 | 0.900 |
| 5.200 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.843 | 0.899 | 0.899 | 0.899 | 0.899 |
| 8.900 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.942 | 0.962 | 0.962 | 0.962 | 0.962 |
| 11.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.958 | 0.958 | 0.958 | 0.958 |
| 14.100 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.791 | 0.865 | 0.865 | 0.865 | 0.865 |
| 15.400 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.846 | 0.846 | 0.846 | 0.846 |
| 17.300 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.760 | 0.845 | 0.845 | 0.845 | 0.845 |
| 18.800 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.728 | 0.824 | 0.824 | 0.824 | 0.824 |
| 20.100 | 0.255 | 0.255 | 0.255 | 0.255 | 0.255 | 0.719 | 0.818 | 0.818 | 0.818 | 0.818 |
| 20.600 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.727 | 0.824 | 0.824 | 0.824 | 0.824 |
| 22.300 | 0.274 | 0.274 | 0.274 | 0.274 | 0.274 | 0.726 | 0.823 | 0.823 | 0.823 | 0.823 |
| 23.900 | 0.235 | 0.235 | 0.235 | 0.235 | 0.235 | 0.712 | 0.814 | 0.814 | 0.814 | 0.814 |
| 25.500 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.716 | 0.816 | 0.816 | 0.816 | 0.816 |
| 26.500 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.710 | 0.812 | 0.812 | 0.812 | 0.812 |
| 28.100 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.716 | 0.817 | 0.817 | 0.817 | 0.817 |
| 29.700 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.746 | 0.835 | 0.835 | 0.835 | 0.835 |
| 30.700 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.760 | 0.845 | 0.845 | 0.845 | 0.845 |
| 33.200 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.782 | 0.859 | 0.859 | 0.859 | 0.859 |
| 34.500 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.781 | 0.859 | 0.859 | 0.859 | 0.859 |
| 36.600 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.784 | 0.861 | 0.861 | 0.861 | 0.861 |
| 38.100 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.774 | 0.854 | 0.854 | 0.854 | 0.854 |
| 39.700 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.733 | 0.827 | 0.827 | 0.827 | 0.827 |
| 40.800 | 0.265 | 0.265 | 0.265 | 0.265 | 0.265 | 0.723 | 0.821 | 0.821 | 0.821 | 0.821 |
| 42.900 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.735 | 0.829 | 0.829 | 0.829 | 0.829 |
| 44.700 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.703 | 0.808 | 0.808 | 0.808 | 0.808 |
| 46.700 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.690 | 0.800 | 0.800 | 0.800 | 0.800 |
| 47.500 | 0.181 | 0.181 | 0.181 | 0.181 | 0.181 | 0.691 | 0.800 | 0.800 | 0.800 | 0.800 |
| 48.600 | 0.245 | 0.245 | 0.245 | 0.245 | 0.245 | 0.715 | 0.816 | 0.816 | 0.816 | 0.816 |
| 50.400 | 0.282 | 0.282 | 0.282 | 0.282 | 0.282 | 0.729 | 0.825 | 0.825 | 0.825 | 0.825 |
| 52.400 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.840 | 0.840 | 0.840 | 0.840 |
| 54.000 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.777 | 0.856 | 0.856 | 0.856 | 0.856 |
| 55.600 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.800 | 0.871 | 0.871 | 0.871 | 0.871 |
| 57.800 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.816 | 0.881 | 0.881 | 0.881 | 0.881 |
| 60.100 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.825 | 0.887 | 0.887 | 0.887 | 0.887 |
| 61.700 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.861 | 0.910 | 0.910 | 0.910 | 0.910 |
| 64.100 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.949 | 0.967 | 0.967 | 0.967 | 0.967 |
| 66.900 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.947 | 0.966 | 0.966 | 0.966 | 0.966 |
| 68.800 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.853 | 0.905 | 0.905 | 0.905 | 0.905 |
| 70.300 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.816 | 0.881 | 0.881 | 0.881 | 0.881 |
| 72.700 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.854 | 0.854 | 0.854 | 0.854 |
| 74.200 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.828 | 0.828 | 0.828 | 0.828 |
| 76.500 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.716 | 0.817 | 0.817 | 0.817 | 0.817 |
| 77.300 | 0.324 | 0.324 | 0.324 | 0.324 | 0.324 | 0.745 | 0.835 | 0.835 | 0.835 | 0.835 |
| 80.200 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.771 | 0.852 | 0.852 | 0.852 | 0.852 |
| 81.600 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.802 | 0.872 | 0.872 | 0.872 | 0.872 |
| 83.500 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.809 | 0.876 | 0.876 | 0.876 | 0.876 |
| 85.100 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.840 | 0.897 | 0.897 | 0.897 | 0.897 |
| 86.500 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.866 | 0.914 | 0.914 | 0.914 | 0.914 |
| 87.900 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.914 | 0.944 | 0.944 | 0.944 | 0.944 |
| 90.000 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.970 | 0.981 | 0.981 | 0.981 | 0.981 |
| 92.500 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.998 | 0.999 | 0.999 | 0.999 | 0.999 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]GAPXL values are the centimeters from the bottom of the heated zone.

# Appendix B

## B-1/SHROUD 1 BUNDLE-AVERAGED GEOMETRY DATA, MAXIMUM RESTRICTION DEFINITION

The data in Appendix B represent the input from card groups 5 and 6 as required by ref. 2 for the B-1/shroud 1 COBRA-IV model based on the maximum restriction definition.

Table B.1. Shroud flow area reductions for the B-1/shroud 1 COBRA-IV model based on the maximum restriction definition

| AXL[a] | FRACTIONAL SHROUD FLOW AREA |
|---|---|
| -47.473 | 1.000 |
| 0.000 | 0.983 |
| 1.800 | 0.915 |
| 3.300 | 0.853 |
| 5.200 | 0.851 |
| 8.900 | 0.947 |
| 11.800 | 0.940 |
| 14.100 | 0.797 |
| 15.400 | 0.766 |
| 17.300 | 0.763 |
| 18.800 | 0.729 |
| 20.100 | 0.718 |
| 20.600 | 0.728 |
| 22.300 | 0.681 |
| 23.900 | 0.662 |
| 25.500 | 0.715 |
| 26.500 | 0.709 |
| 28.100 | 0.716 |
| 29.700 | 0.726 |
| 30.700 | 0.764 |
| 33.200 | 0.787 |
| 34.500 | 0.786 |
| 36.600 | 0.790 |
| 38.100 | 0.779 |
| 39.700 | 0.734 |
| 40.800 | 0.706 |
| 42.900 | 0.736 |
| 44.700 | 0.681 |
| 46.700 | 0.626 |
| 47.500 | 0.673 |
| 49.600 | 0.699 |
| 50.400 | 0.724 |
| 52.400 | 0.756 |
| 54.000 | 0.782 |
| 55.600 | 0.806 |
| 57.800 | 0.823 |
| 60.100 | 0.832 |
| 61.700 | 0.869 |
| 64.100 | 0.954 |
| 66.900 | 0.952 |
| 68.800 | 0.860 |
| 70.300 | 0.822 |
| 72.700 | 0.779 |
| 74.200 | 0.735 |
| 76.500 | 0.635 |
| 77.300 | 0.682 |
| 80.200 | 0.776 |
| 81.600 | 0.808 |
| 83.500 | 0.815 |
| 85.100 | 0.847 |
| 86.500 | 0.874 |
| 87.900 | 0.920 |
| 90.000 | 0.973 |
| 92.500 | 0.998 |
| 96.190 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table B.2. AFACT values for the B-1/shroud 1 COBRA-IV model based on the maximum restriction definition

| AXL[a] | VALUE OF I IS: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.993 | 0.989 | 0.989 | 0.989 | 0.993 | 0.984 | 0.973 | 0.973 | 0.973 | 0.984 |
| 1.800 | 0.964 | 0.944 | 0.944 | 0.944 | 0.964 | 0.923 | 0.867 | 0.867 | 0.867 | 0.923 |
| 3.300 | 0.937 | 0.903 | 0.903 | 0.903 | 0.937 | 0.867 | 0.770 | 0.770 | 0.770 | 0.867 |
| 5.200 | 0.936 | 0.902 | 0.902 | 0.902 | 0.936 | 0.865 | 0.767 | 0.767 | 0.767 | 0.865 |
| 8.900 | 0.977 | 0.965 | 0.965 | 0.965 | 0.977 | 0.952 | 0.917 | 0.917 | 0.917 | 0.952 |
| 11.800 | 0.974 | 0.960 | 0.960 | 0.960 | 0.974 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 |
| 14.100 | 0.913 | 0.866 | 0.866 | 0.866 | 0.913 | 0.817 | 0.683 | 0.683 | 0.683 | 0.817 |
| 15.400 | 0.900 | 0.846 | 0.846 | 0.846 | 0.900 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 |
| 17.300 | 0.899 | 0.844 | 0.844 | 0.844 | 0.899 | 0.787 | 0.631 | 0.631 | 0.631 | 0.787 |
| 18.800 | 0.884 | 0.822 | 0.822 | 0.822 | 0.884 | 0.756 | 0.577 | 0.577 | 0.577 | 0.756 |
| 20.100 | 0.880 | 0.815 | 0.815 | 0.815 | 0.880 | 0.746 | 0.561 | 0.561 | 0.561 | 0.746 |
| 20.600 | 0.884 | 0.821 | 0.821 | 0.821 | 0.884 | 0.755 | 0.576 | 0.576 | 0.576 | 0.755 |
| 22.300 | 0.864 | 0.790 | 0.790 | 0.790 | 0.864 | 0.713 | 0.503 | 0.503 | 0.503 | 0.713 |
| 23.900 | 0.856 | 0.778 | 0.778 | 0.778 | 0.856 | 0.695 | 0.473 | 0.473 | 0.473 | 0.695 |
| 25.500 | 0.878 | 0.813 | 0.813 | 0.813 | 0.878 | 0.743 | 0.556 | 0.556 | 0.556 | 0.743 |
| 26.500 | 0.876 | 0.809 | 0.809 | 0.809 | 0.876 | 0.738 | 0.546 | 0.546 | 0.546 | 0.738 |
| 28.100 | 0.879 | 0.813 | 0.813 | 0.813 | 0.879 | 0.744 | 0.557 | 0.557 | 0.557 | 0.744 |
| 29.700 | 0.883 | 0.820 | 0.820 | 0.820 | 0.883 | 0.753 | 0.573 | 0.573 | 0.573 | 0.753 |
| 30.700 | 0.899 | 0.845 | 0.845 | 0.845 | 0.899 | 0.787 | 0.632 | 0.632 | 0.632 | 0.787 |
| 33.200 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 | 0.808 | 0.668 | 0.668 | 0.668 | 0.808 |
| 34.500 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 | 0.808 | 0.667 | 0.667 | 0.667 | 0.808 |
| 36.600 | 0.910 | 0.862 | 0.862 | 0.862 | 0.910 | 0.810 | 0.672 | 0.672 | 0.672 | 0.810 |
| 38.100 | 0.905 | 0.854 | 0.854 | 0.854 | 0.905 | 0.801 | 0.655 | 0.655 | 0.655 | 0.801 |
| 39.700 | 0.914 | 0.825 | 0.825 | 0.825 | 0.886 | 0.815 | 0.585 | 0.585 | 0.585 | 0.760 |
| 40.800 | 0.905 | 0.807 | 0.807 | 0.807 | 0.875 | 0.796 | 0.542 | 0.542 | 0.542 | 0.735 |
| 42.900 | 0.887 | 0.827 | 0.827 | 0.827 | 0.887 | 0.762 | 0.589 | 0.589 | 0.589 | 0.762 |
| 44.700 | 0.913 | 0.790 | 0.790 | 0.790 | 0.864 | 0.829 | 0.503 | 0.503 | 0.503 | 0.713 |
| 46.700 | 0.898 | 0.754 | 0.754 | 0.754 | 0.840 | 0.800 | 0.416 | 0.416 | 0.416 | 0.663 |
| 47.500 | 0.911 | 0.785 | 0.785 | 0.785 | 0.860 | 0.825 | 0.490 | 0.490 | 0.490 | 0.705 |
| 48.600 | 0.871 | 0.802 | 0.802 | 0.802 | 0.871 | 0.728 | 0.530 | 0.530 | 0.530 | 0.728 |
| 50.400 | 0.882 | 0.818 | 0.818 | 0.818 | 0.882 | 0.751 | 0.569 | 0.569 | 0.569 | 0.751 |
| 52.400 | 0.896 | 0.840 | 0.840 | 0.840 | 0.896 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 |
| 54.000 | 0.907 | 0.857 | 0.857 | 0.857 | 0.907 | 0.804 | 0.660 | 0.660 | 0.660 | 0.804 |
| 55.600 | 0.917 | 0.873 | 0.873 | 0.873 | 0.917 | 0.825 | 0.698 | 0.698 | 0.698 | 0.825 |
| 57.800 | 0.924 | 0.884 | 0.884 | 0.884 | 0.924 | 0.841 | 0.724 | 0.724 | 0.724 | 0.841 |
| 60.100 | 0.928 | 0.889 | 0.889 | 0.889 | 0.928 | 0.849 | 0.738 | 0.738 | 0.738 | 0.849 |
| 61.700 | 0.944 | 0.914 | 0.914 | 0.914 | 0.944 | 0.882 | 0.795 | 0.795 | 0.795 | 0.882 |
| 64.100 | 0.980 | 0.970 | 0.970 | 0.970 | 0.980 | 0.958 | 0.928 | 0.928 | 0.928 | 0.958 |
| 66.900 | 0.979 | 0.968 | 0.968 | 0.968 | 0.979 | 0.957 | 0.925 | 0.925 | 0.925 | 0.957 |
| 68.800 | 0.940 | 0.908 | 0.908 | 0.908 | 0.940 | 0.874 | 0.782 | 0.782 | 0.782 | 0.874 |
| 70.300 | 0.924 | 0.883 | 0.883 | 0.883 | 0.924 | 0.840 | 0.723 | 0.723 | 0.723 | 0.840 |
| 72.700 | 0.906 | 0.855 | 0.855 | 0.855 | 0.906 | 0.801 | 0.656 | 0.656 | 0.656 | 0.801 |
| 74.200 | 0.887 | 0.825 | 0.825 | 0.825 | 0.925 | 0.761 | 0.586 | 0.586 | 0.586 | 0.853 |
| 76.500 | 0.844 | 0.760 | 0.760 | 0.760 | 0.897 | 0.671 | 0.431 | 0.431 | 0.431 | 0.798 |
| 77.300 | 0.864 | 0.791 | 0.791 | 0.791 | 0.911 | 0.713 | 0.504 | 0.504 | 0.504 | 0.824 |
| 80.200 | 0.904 | 0.852 | 0.852 | 0.852 | 0.904 | 0.798 | 0.650 | 0.650 | 0.650 | 0.798 |
| 81.600 | 0.918 | 0.874 | 0.874 | 0.874 | 0.918 | 0.827 | 0.701 | 0.701 | 0.701 | 0.827 |
| 83.500 | 0.921 | 0.879 | 0.879 | 0.879 | 0.921 | 0.834 | 0.712 | 0.712 | 0.712 | 0.834 |
| 85.100 | 0.935 | 0.900 | 0.900 | 0.900 | 0.935 | 0.862 | 0.762 | 0.762 | 0.762 | 0.862 |
| 86.500 | 0.946 | 0.917 | 0.917 | 0.917 | 0.946 | 0.886 | 0.803 | 0.803 | 0.803 | 0.886 |
| 87.900 | 0.966 | 0.948 | 0.948 | 0.948 | 0.966 | 0.928 | 0.876 | 0.876 | 0.876 | 0.928 |
| 90.000 | 0.988 | 0.982 | 0.982 | 0.982 | 0.988 | 0.976 | 0.958 | 0.958 | 0.958 | 0.976 |
| 92.500 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 | 0.998 | 0.997 | 0.997 | 0.997 | 0.998 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table B.2 (continued)

| AXL[a] | VALUE OF I IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.984 | 0.973 | 0.973 | 0.973 | 0.984 | 0.984 | 0.973 | 0.973 | 0.973 | 0.984 |
| 1.800 | 0.923 | 0.867 | 0.867 | 0.867 | 0.923 | 0.923 | 0.867 | 0.867 | 0.867 | 0.923 |
| 3.300 | 0.867 | 0.770 | 0.770 | 0.770 | 0.867 | 0.867 | 0.770 | 0.770 | 0.770 | 0.867 |
| 5.200 | 0.865 | 0.767 | 0.767 | 0.767 | 0.865 | 0.865 | 0.767 | 0.767 | 0.767 | 0.865 |
| 8.900 | 0.952 | 0.917 | 0.917 | 0.917 | 0.952 | 0.952 | 0.917 | 0.917 | 0.917 | 0.952 |
| 11.800 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 |
| 14.100 | 0.817 | 0.683 | 0.683 | 0.683 | 0.817 | 0.817 | 0.683 | 0.683 | 0.683 | 0.817 |
| 15.400 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 |
| 17.300 | 0.787 | 0.631 | 0.631 | 0.631 | 0.787 | 0.787 | 0.631 | 0.631 | 0.631 | 0.787 |
| 18.800 | 0.756 | 0.577 | 0.577 | 0.577 | 0.756 | 0.756 | 0.577 | 0.577 | 0.577 | 0.756 |
| 20.100 | 0.746 | 0.561 | 0.561 | 0.561 | 0.746 | 0.746 | 0.561 | 0.561 | 0.561 | 0.746 |
| 20.600 | 0.755 | 0.576 | 0.576 | 0.576 | 0.755 | 0.755 | 0.576 | 0.576 | 0.576 | 0.755 |
| 22.300 | 0.713 | 0.503 | 0.503 | 0.503 | 0.713 | 0.713 | 0.503 | 0.503 | 0.503 | 0.713 |
| 23.900 | 0.695 | 0.473 | 0.473 | 0.473 | 0.695 | 0.695 | 0.473 | 0.473 | 0.473 | 0.695 |
| 25.500 | 0.743 | 0.556 | 0.556 | 0.556 | 0.743 | 0.743 | 0.556 | 0.556 | 0.556 | 0.743 |
| 26.500 | 0.738 | 0.546 | 0.546 | 0.546 | 0.738 | 0.738 | 0.546 | 0.546 | 0.546 | 0.738 |
| 28.100 | 0.744 | 0.557 | 0.557 | 0.557 | 0.744 | 0.744 | 0.557 | 0.557 | 0.557 | 0.744 |
| 29.700 | 0.753 | 0.573 | 0.573 | 0.573 | 0.753 | 0.753 | 0.573 | 0.573 | 0.573 | 0.753 |
| 30.700 | 0.787 | 0.632 | 0.632 | 0.632 | 0.787 | 0.787 | 0.632 | 0.632 | 0.632 | 0.787 |
| 33.200 | 0.808 | 0.668 | 0.668 | 0.668 | 0.808 | 0.808 | 0.668 | 0.668 | 0.668 | 0.808 |
| 34.500 | 0.808 | 0.667 | 0.667 | 0.667 | 0.808 | 0.808 | 0.667 | 0.667 | 0.667 | 0.808 |
| 36.600 | 0.810 | 0.672 | 0.672 | 0.672 | 0.810 | 0.810 | 0.672 | 0.672 | 0.672 | 0.810 |
| 38.100 | 0.801 | 0.655 | 0.655 | 0.655 | 0.801 | 0.801 | 0.655 | 0.655 | 0.655 | 0.801 |
| 39.700 | 0.760 | 0.585 | 0.585 | 0.585 | 0.760 | 0.760 | 0.585 | 0.585 | 0.585 | 0.760 |
| 40.800 | 0.735 | 0.542 | 0.542 | 0.542 | 0.735 | 0.735 | 0.542 | 0.542 | 0.542 | 0.735 |
| 42.900 | 0.762 | 0.589 | 0.589 | 0.589 | 0.762 | 0.762 | 0.589 | 0.589 | 0.589 | 0.762 |
| 44.700 | 0.777 | 0.503 | 0.503 | 0.503 | 0.713 | 0.713 | 0.503 | 0.503 | 0.503 | 0.713 |
| 46.700 | 0.738 | 0.416 | 0.416 | 0.416 | 0.663 | 0.663 | 0.416 | 0.416 | 0.416 | 0.663 |
| 47.500 | 0.771 | 0.490 | 0.490 | 0.490 | 0.705 | 0.705 | 0.490 | 0.490 | 0.490 | 0.705 |
| 48.600 | 0.728 | 0.530 | 0.530 | 0.530 | 0.728 | 0.728 | 0.530 | 0.530 | 0.530 | 0.728 |
| 50.400 | 0.751 | 0.569 | 0.569 | 0.569 | 0.751 | 0.751 | 0.569 | 0.569 | 0.569 | 0.751 |
| 52.400 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 |
| 54.000 | 0.804 | 0.660 | 0.660 | 0.660 | 0.804 | 0.804 | 0.660 | 0.660 | 0.660 | 0.804 |
| 55.600 | 0.825 | 0.698 | 0.698 | 0.698 | 0.825 | 0.825 | 0.698 | 0.698 | 0.698 | 0.825 |
| 57.800 | 0.841 | 0.724 | 0.724 | 0.724 | 0.841 | 0.841 | 0.724 | 0.724 | 0.724 | 0.841 |
| 60.100 | 0.849 | 0.738 | 0.738 | 0.738 | 0.849 | 0.849 | 0.738 | 0.738 | 0.738 | 0.849 |
| 61.700 | 0.882 | 0.795 | 0.795 | 0.795 | 0.882 | 0.882 | 0.795 | 0.795 | 0.795 | 0.882 |
| 64.100 | 0.958 | 0.928 | 0.928 | 0.928 | 0.958 | 0.958 | 0.928 | 0.928 | 0.928 | 0.958 |
| 66.900 | 0.957 | 0.925 | 0.925 | 0.925 | 0.957 | 0.957 | 0.925 | 0.925 | 0.925 | 0.957 |
| 68.800 | 0.874 | 0.782 | 0.782 | 0.782 | 0.874 | 0.874 | 0.782 | 0.782 | 0.782 | 0.874 |
| 70.300 | 0.840 | 0.723 | 0.723 | 0.723 | 0.840 | 0.840 | 0.723 | 0.723 | 0.723 | 0.840 |
| 72.700 | 0.801 | 0.656 | 0.656 | 0.656 | 0.801 | 0.801 | 0.656 | 0.656 | 0.656 | 0.801 |
| 74.200 | 0.761 | 0.586 | 0.586 | 0.586 | 0.853 | 0.761 | 0.586 | 0.586 | 0.586 | 0.853 |
| 76.500 | 0.671 | 0.431 | 0.431 | 0.431 | 0.798 | 0.671 | 0.431 | 0.431 | 0.431 | 0.799 |
| 77.300 | 0.713 | 0.504 | 0.504 | 0.504 | 0.824 | 0.713 | 0.504 | 0.504 | 0.504 | 0.824 |
| 80.200 | 0.798 | 0.650 | 0.650 | 0.650 | 0.798 | 0.798 | 0.650 | 0.650 | 0.650 | 0.798 |
| 81.600 | 0.827 | 0.701 | 0.701 | 0.701 | 0.827 | 0.827 | 0.701 | 0.701 | 0.701 | 0.827 |
| 83.500 | 0.834 | 0.712 | 0.712 | 0.712 | 0.834 | 0.834 | 0.712 | 0.712 | 0.712 | 0.834 |
| 85.100 | 0.862 | 0.762 | 0.762 | 0.762 | 0.862 | 0.862 | 0.762 | 0.762 | 0.762 | 0.862 |
| 86.500 | 0.886 | 0.803 | 0.803 | 0.803 | 0.886 | 0.886 | 0.803 | 0.803 | 0.803 | 0.886 |
| 87.900 | 0.928 | 0.876 | 0.876 | 0.876 | 0.928 | 0.928 | 0.876 | 0.876 | 0.876 | 0.928 |
| 90.000 | 0.976 | 0.958 | 0.958 | 0.958 | 0.976 | 0.976 | 0.958 | 0.958 | 0.958 | 0.976 |
| 92.500 | 0.998 | 0.997 | 0.997 | 0.997 | 0.998 | 0.998 | 0.997 | 0.997 | 0.997 | 0.998 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table B.2 (continued)

| AXL[a] | VALUE OF I IS: 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.993 | 0.989 | 0.989 | 0.989 | 0.993 |
| 1.800 | 0.964 | 0.944 | 0.944 | 0.944 | 0.964 |
| 3.300 | 0.937 | 0.903 | 0.903 | 0.903 | 0.937 |
| 5.200 | 0.936 | 0.902 | 0.902 | 0.902 | 0.936 |
| 8.900 | 0.977 | 0.965 | 0.965 | 0.965 | 0.977 |
| 11.800 | 0.974 | 0.960 | 0.960 | 0.960 | 0.974 |
| 14.100 | 0.913 | 0.866 | 0.866 | 0.866 | 0.913 |
| 15.400 | 0.900 | 0.846 | 0.846 | 0.846 | 0.900 |
| 17.300 | 0.899 | 0.844 | 0.844 | 0.844 | 0.899 |
| 18.800 | 0.884 | 0.822 | 0.822 | 0.822 | 0.884 |
| 20.100 | 0.880 | 0.815 | 0.815 | 0.815 | 0.880 |
| 20.600 | 0.884 | 0.821 | 0.821 | 0.821 | 0.884 |
| 22.300 | 0.864 | 0.790 | 0.790 | 0.790 | 0.864 |
| 23.900 | 0.856 | 0.778 | 0.778 | 0.778 | 0.856 |
| 25.500 | 0.878 | 0.813 | 0.813 | 0.813 | 0.878 |
| 26.500 | 0.876 | 0.809 | 0.809 | 0.809 | 0.876 |
| 28.100 | 0.879 | 0.813 | 0.813 | 0.813 | 0.879 |
| 29.700 | 0.883 | 0.820 | 0.820 | 0.820 | 0.883 |
| 30.700 | 0.899 | 0.845 | 0.845 | 0.845 | 0.899 |
| 33.200 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 |
| 34.500 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 |
| 36.600 | 0.910 | 0.862 | 0.862 | 0.862 | 0.910 |
| 38.100 | 0.905 | 0.854 | 0.854 | 0.854 | 0.905 |
| 39.700 | 0.886 | 0.825 | 0.825 | 0.825 | 0.886 |
| 40.800 | 0.875 | 0.807 | 0.807 | 0.807 | 0.875 |
| 42.900 | 0.887 | 0.827 | 0.827 | 0.827 | 0.887 |
| 44.700 | 0.864 | 0.790 | 0.790 | 0.790 | 0.864 |
| 46.700 | 0.840 | 0.754 | 0.754 | 0.754 | 0.840 |
| 47.500 | 0.860 | 0.785 | 0.785 | 0.785 | 0.860 |
| 48.600 | 0.871 | 0.802 | 0.802 | 0.802 | 0.871 |
| 50.400 | 0.882 | 0.818 | 0.818 | 0.818 | 0.882 |
| 52.400 | 0.896 | 0.840 | 0.840 | 0.840 | 0.896 |
| 54.000 | 0.907 | 0.857 | 0.857 | 0.857 | 0.907 |
| 55.600 | 0.917 | 0.873 | 0.873 | 0.873 | 0.917 |
| 57.800 | 0.924 | 0.884 | 0.884 | 0.884 | 0.924 |
| 60.100 | 0.928 | 0.889 | 0.889 | 0.889 | 0.928 |
| 61.700 | 0.944 | 0.914 | 0.914 | 0.914 | 0.944 |
| 64.100 | 0.980 | 0.970 | 0.970 | 0.970 | 0.980 |
| 66.900 | 0.979 | 0.968 | 0.968 | 0.968 | 0.979 |
| 68.800 | 0.940 | 0.908 | 0.908 | 0.908 | 0.940 |
| 70.300 | 0.924 | 0.883 | 0.883 | 0.883 | 0.924 |
| 72.700 | 0.906 | 0.855 | 0.855 | 0.855 | 0.906 |
| 74.200 | 0.887 | 0.825 | 0.825 | 0.825 | 0.887 |
| 76.500 | 0.844 | 0.760 | 0.760 | 0.760 | 0.844 |
| 77.300 | 0.864 | 0.791 | 0.791 | 0.791 | 0.864 |
| 80.200 | 0.904 | 0.852 | 0.852 | 0.852 | 0.904 |
| 81.600 | 0.918 | 0.874 | 0.874 | 0.874 | 0.918 |
| 83.500 | 0.921 | 0.879 | 0.879 | 0.879 | 0.921 |
| 85.100 | 0.935 | 0.900 | 0.900 | 0.900 | 0.935 |
| 86.500 | 0.946 | 0.917 | 0.917 | 0.917 | 0.946 |
| 87.900 | 0.966 | 0.948 | 0.948 | 0.948 | 0.966 |
| 90.000 | 0.988 | 0.982 | 0.982 | 0.982 | 0.988 |
| 92.500 | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table B.3. GFACT values for the B-1/shroud 1 COBRA-IV model based on the maximum restriction definition

| GAPXL[a] | VALUE OF K IS: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.988 | 0.981 | 0.988 | 0.949 | 0.988 | 0.949 | 0.988 | 0.949 | 0.981 | 0.981 |
| 1.800 | 0.941 | 0.908 | 0.941 | 0.756 | 0.941 | 0.756 | 0.941 | 0.756 | 0.908 | 0.908 |
| 3.300 | 0.900 | 0.845 | 0.900 | 0.589 | 0.900 | 0.589 | 0.900 | 0.589 | 0.845 | 0.845 |
| 5.200 | 0.899 | 0.843 | 0.899 | 0.584 | 0.899 | 0.584 | 0.899 | 0.584 | 0.843 | 0.843 |
| 8.900 | 0.962 | 0.942 | 0.962 | 0.846 | 0.962 | 0.846 | 0.962 | 0.846 | 0.942 | 0.942 |
| 11.800 | 0.958 | 0.934 | 0.958 | 0.826 | 0.958 | 0.826 | 0.958 | 0.826 | 0.934 | 0.934 |
| 14.100 | 0.865 | 0.791 | 0.865 | 0.446 | 0.865 | 0.446 | 0.865 | 0.446 | 0.791 | 0.791 |
| 15.400 | 0.846 | 0.762 | 0.846 | 0.369 | 0.846 | 0.369 | 0.846 | 0.369 | 0.762 | 0.762 |
| 17.300 | 0.845 | 0.760 | 0.845 | 0.363 | 0.845 | 0.363 | 0.845 | 0.363 | 0.760 | 0.760 |
| 18.800 | 0.824 | 0.728 | 0.824 | 0.278 | 0.824 | 0.278 | 0.824 | 0.278 | 0.728 | 0.728 |
| 20.100 | 0.818 | 0.719 | 0.818 | 0.254 | 0.818 | 0.254 | 0.818 | 0.254 | 0.719 | 0.719 |
| 20.600 | 0.824 | 0.727 | 0.824 | 0.277 | 0.824 | 0.277 | 0.824 | 0.277 | 0.727 | 0.727 |
| 22.300 | 0.797 | 0.685 | 0.797 | 0.166 | 0.797 | 0.166 | 0.797 | 0.166 | 0.685 | 0.685 |
| 23.900 | 0.786 | 0.669 | 0.786 | 0.121 | 0.786 | 0.121 | 0.786 | 0.121 | 0.669 | 0.669 |
| 25.500 | 0.816 | 0.716 | 0.816 | 0.246 | 0.816 | 0.246 | 0.816 | 0.246 | 0.716 | 0.716 |
| 26.500 | 0.812 | 0.710 | 0.812 | 0.231 | 0.812 | 0.231 | 0.812 | 0.231 | 0.710 | 0.710 |
| 28.100 | 0.817 | 0.716 | 0.817 | 0.248 | 0.817 | 0.248 | 0.817 | 0.248 | 0.716 | 0.716 |
| 29.700 | 0.823 | 0.726 | 0.823 | 0.272 | 0.823 | 0.272 | 0.823 | 0.272 | 0.726 | 0.726 |
| 30.700 | 0.845 | 0.760 | 0.845 | 0.364 | 0.845 | 0.364 | 0.845 | 0.364 | 0.760 | 0.760 |
| 33.200 | 0.859 | 0.782 | 0.859 | 0.422 | 0.859 | 0.422 | 0.859 | 0.422 | 0.782 | 0.782 |
| 34.500 | 0.859 | 0.781 | 0.859 | 0.420 | 0.859 | 0.420 | 0.859 | 0.420 | 0.781 | 0.781 |
| 36.600 | 0.861 | 0.784 | 0.861 | 0.428 | 0.861 | 0.428 | 0.861 | 0.428 | 0.784 | 0.784 |
| 38.100 | 0.854 | 0.774 | 0.854 | 0.401 | 0.854 | 0.401 | 0.854 | 0.401 | 0.774 | 0.774 |
| 39.700 | 0.827 | 0.733 | 0.827 | 0.291 | 0.827 | 0.291 | 0.827 | 0.291 | 0.733 | 0.733 |
| 40.800 | 0.811 | 0.708 | 0.811 | 0.225 | 0.811 | 0.225 | 0.811 | 0.225 | 0.708 | 0.708 |
| 42.900 | 0.829 | 0.735 | 0.829 | 0.297 | 0.829 | 0.297 | 0.829 | 0.297 | 0.735 | 0.735 |
| 44.700 | 0.797 | 0.685 | 0.797 | 0.166 | 0.797 | 0.166 | 0.797 | 0.166 | 0.685 | 0.685 |
| 46.700 | 0.765 | 0.637 | 0.765 | 0.037 | 0.765 | 0.037 | 0.765 | 0.037 | 0.637 | 0.637 |
| 47.500 | 0.792 | 0.678 | 0.792 | 0.146 | 0.792 | 0.146 | 0.792 | 0.146 | 0.678 | 0.678 |
| 48.600 | 0.807 | 0.701 | 0.807 | 0.207 | 0.807 | 0.207 | 0.807 | 0.207 | 0.701 | 0.701 |
| 50.400 | 0.821 | 0.723 | 0.821 | 0.266 | 0.821 | 0.266 | 0.821 | 0.266 | 0.723 | 0.723 |
| 52.400 | 0.840 | 0.753 | 0.840 | 0.346 | 0.840 | 0.346 | 0.840 | 0.346 | 0.753 | 0.753 |
| 54.000 | 0.856 | 0.777 | 0.856 | 0.409 | 0.856 | 0.409 | 0.856 | 0.409 | 0.777 | 0.777 |
| 55.600 | 0.871 | 0.800 | 0.871 | 0.470 | 0.871 | 0.470 | 0.871 | 0.470 | 0.800 | 0.800 |
| 57.800 | 0.881 | 0.816 | 0.881 | 0.513 | 0.881 | 0.513 | 0.881 | 0.513 | 0.816 | 0.816 |
| 60.100 | 0.887 | 0.825 | 0.887 | 0.536 | 0.887 | 0.536 | 0.887 | 0.536 | 0.825 | 0.825 |
| 61.700 | 0.910 | 0.861 | 0.910 | 0.632 | 0.910 | 0.632 | 0.910 | 0.632 | 0.861 | 0.861 |
| 64.100 | 0.967 | 0.949 | 0.967 | 0.866 | 0.967 | 0.866 | 0.967 | 0.866 | 0.949 | 0.949 |
| 66.900 | 0.966 | 0.947 | 0.966 | 0.860 | 0.966 | 0.860 | 0.966 | 0.860 | 0.947 | 0.947 |
| 68.800 | 0.905 | 0.853 | 0.905 | 0.610 | 0.905 | 0.610 | 0.905 | 0.610 | 0.853 | 0.853 |
| 70.300 | 0.881 | 0.816 | 0.881 | 0.511 | 0.881 | 0.511 | 0.881 | 0.511 | 0.816 | 0.816 |
| 72.700 | 0.854 | 0.775 | 0.854 | 0.403 | 0.854 | 0.403 | 0.854 | 0.403 | 0.775 | 0.775 |
| 74.200 | 0.827 | 0.733 | 0.827 | 0.292 | 0.827 | 0.292 | 0.827 | 0.292 | 0.733 | 0.733 |
| 76.500 | 0.771 | 0.645 | 0.771 | 0.059 | 0.771 | 0.059 | 0.771 | 0.059 | 0.645 | 0.645 |
| 77.300 | 0.797 | 0.686 | 0.797 | 0.167 | 0.797 | 0.167 | 0.797 | 0.167 | 0.686 | 0.686 |
| 80.200 | 0.852 | 0.771 | 0.852 | 0.393 | 0.852 | 0.393 | 0.852 | 0.393 | 0.771 | 0.771 |
| 81.600 | 0.872 | 0.802 | 0.872 | 0.475 | 0.872 | 0.475 | 0.872 | 0.475 | 0.802 | 0.802 |
| 83.500 | 0.876 | 0.809 | 0.876 | 0.493 | 0.876 | 0.493 | 0.876 | 0.493 | 0.809 | 0.809 |
| 85.100 | 0.897 | 0.840 | 0.897 | 0.576 | 0.897 | 0.576 | 0.897 | 0.576 | 0.840 | 0.840 |
| 86.500 | 0.914 | 0.866 | 0.914 | 0.645 | 0.914 | 0.645 | 0.914 | 0.645 | 0.866 | 0.866 |
| 87.900 | 0.944 | 0.914 | 0.944 | 0.772 | 0.944 | 0.772 | 0.944 | 0.772 | 0.914 | 0.914 |
| 90.000 | 0.981 | 0.970 | 0.981 | 0.921 | 0.981 | 0.921 | 0.981 | 0.921 | 0.970 | 0.970 |
| 92.500 | 0.999 | 0.998 | 0.999 | 0.994 | 0.999 | 0.994 | 0.999 | 0.994 | 0.998 | 0.998 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table B.3 (continued)

| GAPXL[a] | VALUE OF K IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.981 | 0.981 | 0.949 |
| 1.800 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.908 | 0.908 | 0.756 |
| 3.300 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.845 | 0.845 | 0.589 |
| 5.200 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.843 | 0.843 | 0.584 |
| 8.900 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.942 | 0.942 | 0.846 |
| 11.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.934 | 0.826 |
| 14.100 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.791 | 0.791 | 0.446 |
| 15.400 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.762 | 0.369 |
| 17.300 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.760 | 0.760 | 0.363 |
| 18.800 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.728 | 0.728 | 0.278 |
| 20.100 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.719 | 0.719 | 0.254 |
| 20.600 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.727 | 0.727 | 0.277 |
| 22.300 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.685 | 0.685 | 0.166 |
| 23.900 | 0.121 | 0.121 | 0.121 | 0.121 | 0.121 | 0.121 | 0.121 | 0.669 | 0.669 | 0.121 |
| 25.500 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.716 | 0.716 | 0.246 |
| 26.500 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.710 | 0.710 | 0.231 |
| 28.100 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.716 | 0.716 | 0.248 |
| 29.700 | 0.272 | 0.272 | 0.272 | 0.272 | 0.272 | 0.272 | 0.272 | 0.726 | 0.726 | 0.272 |
| 30.700 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.760 | 0.760 | 0.364 |
| 33.200 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.782 | 0.782 | 0.422 |
| 34.500 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.781 | 0.781 | 0.420 |
| 36.600 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.784 | 0.784 | 0.428 |
| 38.100 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.774 | 0.774 | 0.401 |
| 39.700 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.733 | 0.733 | 0.291 |
| 40.800 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.708 | 0.708 | 0.225 |
| 42.900 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.735 | 0.735 | 0.297 |
| 44.700 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.685 | 0.685 | 0.166 |
| 46.700 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.637 | 0.637 | 0.037 |
| 47.500 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.678 | 0.678 | 0.146 |
| 48.600 | 0.207 | 0.207 | 0.207 | 0.207 | 0.207 | 0.207 | 0.207 | 0.701 | 0.701 | 0.207 |
| 50.400 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.723 | 0.723 | 0.266 |
| 52.400 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.753 | 0.346 |
| 54.000 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.777 | 0.777 | 0.409 |
| 55.600 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.800 | 0.800 | 0.470 |
| 57.800 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.816 | 0.816 | 0.513 |
| 60.100 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.825 | 0.825 | 0.536 |
| 61.700 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.861 | 0.861 | 0.632 |
| 64.100 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.949 | 0.949 | 0.866 |
| 66.900 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.947 | 0.947 | 0.860 |
| 68.800 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.853 | 0.853 | 0.610 |
| 70.300 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.816 | 0.816 | 0.511 |
| 72.700 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.775 | 0.403 |
| 74.200 | 0.292 | 0.292 | 0.292 | 0.292 | 0.292 | 0.292 | 0.292 | 0.733 | 0.733 | 0.292 |
| 76.500 | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.645 | 0.645 | 0.059 |
| 77.300 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.686 | 0.686 | 0.167 |
| 80.200 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.771 | 0.771 | 0.393 |
| 81.600 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.802 | 0.802 | 0.475 |
| 83.500 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.809 | 0.809 | 0.493 |
| 85.100 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.840 | 0.840 | 0.576 |
| 86.500 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.866 | 0.866 | 0.645 |
| 87.900 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.914 | 0.914 | 0.772 |
| 90.000 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.970 | 0.970 | 0.921 |
| 92.500 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.998 | 0.998 | 0.994 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table B.3 (continued)

| GAPXL[a] | VALUE OF K IS: 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.981 | 0.981 | 0.949 | 0.949 |
| 1.800 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.908 | 0.908 | 0.756 | 0.756 |
| 3.300 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.845 | 0.845 | 0.589 | 0.589 |
| 5.200 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.843 | 0.843 | 0.584 | 0.584 |
| 8.900 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.942 | 0.942 | 0.846 | 0.846 |
| 11.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.934 | 0.826 | 0.826 |
| 14.100 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.791 | 0.791 | 0.446 | 0.446 |
| 15.400 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.762 | 0.369 | 0.369 |
| 17.300 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.760 | 0.760 | 0.363 | 0.363 |
| 18.800 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.728 | 0.728 | 0.278 | 0.278 |
| 20.100 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.719 | 0.719 | 0.254 | 0.254 |
| 20.600 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.727 | 0.727 | 0.277 | 0.277 |
| 22.300 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.685 | 0.685 | 0.166 | 0.166 |
| 23.900 | 0.121 | 0.121 | 0.121 | 0.121 | 0.121 | 0.121 | 0.669 | 0.669 | 0.121 | 0.121 |
| 25.500 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.716 | 0.716 | 0.246 | 0.246 |
| 26.500 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.710 | 0.710 | 0.231 | 0.231 |
| 28.100 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.716 | 0.716 | 0.248 | 0.248 |
| 29.700 | 0.272 | 0.272 | 0.272 | 0.272 | 0.272 | 0.272 | 0.726 | 0.726 | 0.272 | 0.272 |
| 30.700 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.760 | 0.760 | 0.364 | 0.364 |
| 33.200 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.782 | 0.782 | 0.422 | 0.422 |
| 34.500 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.781 | 0.781 | 0.420 | 0.420 |
| 36.600 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.784 | 0.784 | 0.428 | 0.428 |
| 38.100 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.774 | 0.774 | 0.401 | 0.401 |
| 39.700 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.733 | 0.733 | 0.291 | 0.291 |
| 40.800 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.708 | 0.708 | 0.225 | 0.225 |
| 42.900 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.735 | 0.735 | 0.297 | 0.297 |
| 44.700 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.685 | 0.685 | 0.166 | 0.166 |
| 46.700 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.637 | 0.637 | 0.037 | 0.037 |
| 47.500 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.678 | 0.678 | 0.146 | 0.146 |
| 48.600 | 0.207 | 0.207 | 0.207 | 0.207 | 0.207 | 0.207 | 0.701 | 0.701 | 0.207 | 0.207 |
| 50.400 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.723 | 0.723 | 0.266 | 0.266 |
| 52.400 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.753 | 0.346 | 0.346 |
| 54.000 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.777 | 0.777 | 0.409 | 0.409 |
| 55.600 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.800 | 0.800 | 0.470 | 0.470 |
| 57.800 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.816 | 0.816 | 0.513 | 0.513 |
| 60.100 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.825 | 0.825 | 0.536 | 0.536 |
| 61.700 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.861 | 0.861 | 0.632 | 0.632 |
| 64.100 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.949 | 0.949 | 0.866 | 0.866 |
| 66.900 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.947 | 0.947 | 0.860 | 0.860 |
| 68.800 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.853 | 0.853 | 0.610 | 0.610 |
| 70.300 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.816 | 0.816 | 0.511 | 0.511 |
| 72.700 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.775 | 0.403 | 0.403 |
| 74.200 | 0.292 | 0.292 | 0.292 | 0.292 | 0.292 | 0.292 | 0.733 | 0.733 | 0.292 | 0.292 |
| 76.500 | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.645 | 0.645 | 0.059 | 0.059 |
| 77.300 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.686 | 0.686 | 0.167 | 0.167 |
| 80.200 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.771 | 0.771 | 0.393 | 0.393 |
| 81.600 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.802 | 0.802 | 0.475 | 0.475 |
| 83.500 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.809 | 0.809 | 0.493 | 0.493 |
| 85.100 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.840 | 0.840 | 0.576 | 0.576 |
| 86.500 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.866 | 0.866 | 0.645 | 0.645 |
| 87.900 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.914 | 0.914 | 0.772 | 0.772 |
| 90.000 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.970 | 0.970 | 0.921 | 0.921 |
| 92.500 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.998 | 0.998 | 0.994 | 0.994 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table B.3 (continued)

| GAPXL[a] | VALUE OF K IS: 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.473 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 0.949 | 0.949 | 0.949 | 0.949 | 0.949 | 0.981 | 0.988 | 0.988 | 0.988 | 0.988 |
| 1.800 | 0.756 | 0.756 | 0.756 | 0.756 | 0.756 | 0.908 | 0.941 | 0.941 | 0.941 | 0.941 |
| 3.300 | 0.589 | 0.589 | 0.589 | 0.589 | 0.589 | 0.845 | 0.900 | 0.900 | 0.900 | 0.900 |
| 5.200 | 0.584 | 0.584 | 0.584 | 0.584 | 0.584 | 0.843 | 0.899 | 0.899 | 0.899 | 0.899 |
| 8.900 | 0.846 | 0.846 | 0.846 | 0.846 | 0.846 | 0.942 | 0.962 | 0.962 | 0.962 | 0.962 |
| 11.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.958 | 0.958 | 0.958 | 0.958 |
| 14.100 | 0.446 | 0.446 | 0.446 | 0.446 | 0.446 | 0.791 | 0.865 | 0.865 | 0.865 | 0.865 |
| 15.400 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.846 | 0.846 | 0.846 | 0.846 |
| 17.300 | 0.363 | 0.363 | 0.363 | 0.363 | 0.363 | 0.760 | 0.845 | 0.845 | 0.845 | 0.845 |
| 18.800 | 0.278 | 0.278 | 0.278 | 0.278 | 0.278 | 0.728 | 0.824 | 0.824 | 0.824 | 0.824 |
| 20.100 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.719 | 0.818 | 0.818 | 0.818 | 0.818 |
| 20.600 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.727 | 0.824 | 0.824 | 0.824 | 0.824 |
| 22.300 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.685 | 0.797 | 0.797 | 0.797 | 0.797 |
| 23.900 | 0.121 | 0.121 | 0.121 | 0.121 | 0.121 | 0.669 | 0.786 | 0.786 | 0.786 | 0.786 |
| 25.500 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.716 | 0.816 | 0.816 | 0.816 | 0.816 |
| 26.500 | 0.231 | 0.231 | 0.231 | 0.231 | 0.231 | 0.710 | 0.812 | 0.812 | 0.812 | 0.812 |
| 28.100 | 0.248 | 0.248 | 0.248 | 0.248 | 0.248 | 0.716 | 0.817 | 0.817 | 0.817 | 0.817 |
| 29.700 | 0.272 | 0.272 | 0.272 | 0.272 | 0.272 | 0.726 | 0.823 | 0.823 | 0.823 | 0.823 |
| 30.700 | 0.364 | 0.364 | 0.364 | 0.364 | 0.364 | 0.760 | 0.845 | 0.845 | 0.845 | 0.845 |
| 33.200 | 0.422 | 0.422 | 0.422 | 0.422 | 0.422 | 0.782 | 0.859 | 0.859 | 0.859 | 0.859 |
| 34.500 | 0.420 | 0.420 | 0.420 | 0.420 | 0.420 | 0.781 | 0.859 | 0.859 | 0.859 | 0.859 |
| 36.600 | 0.428 | 0.428 | 0.428 | 0.428 | 0.428 | 0.784 | 0.861 | 0.861 | 0.861 | 0.861 |
| 38.100 | 0.401 | 0.401 | 0.401 | 0.401 | 0.401 | 0.774 | 0.854 | 0.854 | 0.854 | 0.854 |
| 39.700 | 0.291 | 0.291 | 0.291 | 0.291 | 0.291 | 0.733 | 0.827 | 0.827 | 0.827 | 0.827 |
| 40.800 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.708 | 0.811 | 0.811 | 0.811 | 0.811 |
| 42.900 | 0.297 | 0.297 | 0.297 | 0.297 | 0.297 | 0.735 | 0.829 | 0.829 | 0.829 | 0.829 |
| 44.700 | 0.166 | 0.166 | 0.166 | 0.166 | 0.166 | 0.685 | 0.797 | 0.797 | 0.797 | 0.797 |
| 46.700 | 0.037 | 0.037 | 0.037 | 0.037 | 0.037 | 0.637 | 0.765 | 0.765 | 0.765 | 0.765 |
| 47.500 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.678 | 0.792 | 0.792 | 0.792 | 0.792 |
| 48.600 | 0.207 | 0.207 | 0.207 | 0.207 | 0.207 | 0.701 | 0.807 | 0.807 | 0.807 | 0.807 |
| 50.400 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.723 | 0.821 | 0.821 | 0.821 | 0.821 |
| 52.400 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.840 | 0.840 | 0.840 | 0.840 |
| 54.000 | 0.409 | 0.409 | 0.409 | 0.409 | 0.409 | 0.777 | 0.856 | 0.856 | 0.856 | 0.856 |
| 55.600 | 0.470 | 0.470 | 0.470 | 0.470 | 0.470 | 0.800 | 0.871 | 0.871 | 0.871 | 0.871 |
| 57.800 | 0.513 | 0.513 | 0.513 | 0.513 | 0.513 | 0.816 | 0.881 | 0.881 | 0.881 | 0.881 |
| 60.100 | 0.536 | 0.536 | 0.536 | 0.536 | 0.536 | 0.825 | 0.887 | 0.887 | 0.887 | 0.887 |
| 61.700 | 0.632 | 0.632 | 0.632 | 0.632 | 0.632 | 0.861 | 0.910 | 0.910 | 0.910 | 0.910 |
| 64.100 | 0.866 | 0.866 | 0.866 | 0.866 | 0.866 | 0.949 | 0.967 | 0.967 | 0.967 | 0.967 |
| 66.900 | 0.860 | 0.860 | 0.860 | 0.860 | 0.860 | 0.947 | 0.966 | 0.966 | 0.966 | 0.966 |
| 68.800 | 0.610 | 0.610 | 0.610 | 0.610 | 0.610 | 0.853 | 0.905 | 0.905 | 0.905 | 0.905 |
| 70.300 | 0.511 | 0.511 | 0.511 | 0.511 | 0.511 | 0.816 | 0.881 | 0.881 | 0.881 | 0.881 |
| 72.700 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.854 | 0.854 | 0.854 | 0.854 |
| 74.200 | 0.292 | 0.292 | 0.292 | 0.292 | 0.292 | 0.733 | 0.827 | 0.827 | 0.827 | 0.827 |
| 76.500 | 0.059 | 0.059 | 0.059 | 0.059 | 0.059 | 0.645 | 0.771 | 0.771 | 0.771 | 0.771 |
| 77.300 | 0.167 | 0.167 | 0.167 | 0.167 | 0.167 | 0.686 | 0.797 | 0.797 | 0.797 | 0.797 |
| 80.200 | 0.393 | 0.393 | 0.393 | 0.393 | 0.393 | 0.771 | 0.852 | 0.852 | 0.852 | 0.852 |
| 81.600 | 0.475 | 0.475 | 0.475 | 0.475 | 0.475 | 0.802 | 0.872 | 0.872 | 0.872 | 0.872 |
| 83.500 | 0.493 | 0.493 | 0.493 | 0.493 | 0.493 | 0.809 | 0.876 | 0.876 | 0.876 | 0.876 |
| 85.100 | 0.576 | 0.576 | 0.576 | 0.576 | 0.576 | 0.840 | 0.897 | 0.897 | 0.897 | 0.897 |
| 86.500 | 0.645 | 0.645 | 0.645 | 0.645 | 0.645 | 0.866 | 0.914 | 0.914 | 0.914 | 0.914 |
| 87.900 | 0.772 | 0.772 | 0.772 | 0.772 | 0.772 | 0.914 | 0.944 | 0.944 | 0.944 | 0.944 |
| 90.000 | 0.921 | 0.921 | 0.921 | 0.921 | 0.921 | 0.970 | 0.981 | 0.981 | 0.981 | 0.981 |
| 92.500 | 0.994 | 0.994 | 0.994 | 0.994 | 0.994 | 0.998 | 0.999 | 0.999 | 0.999 | 0.999 |
| 96.190 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]GAPXL values are the centimeters from the bottom of the heated zone.

# Appendix C

## B-2/SHROUD 1 BUNDLE-AVERAGED GEOMETRY DATA, MINIMUM RESTRICTION DEFINITION

The data in Appendix C represent the input from card groups 5 and 6 as required by ref. 2 for the B-2/shroud 1 COBRA-IV model based on the minimum restriction definition.

Table C.1. Shroud flow area reductions for the B-2/shroud I COBRA-IV model based on the minimum restriction definition

| AXL[a] | FRACTIONAL SHROUD FLOW AREA |
|---|---|
| -47.676 | 1.000 |
| 0.000 | 1.003 |
| 1.800 | 0.940 |
| 3.400 | 0.872 |
| 5.000 | 0.877 |
| 6.900 | 0.906 |
| 8.900 | 0.959 |
| 11.500 | 0.957 |
| 13.300 | 0.897 |
| 15.100 | 0.859 |
| 16.800 | 0.821 |
| 18.100 | 0.802 |
| 19.500 | 0.772 |
| 21.400 | 0.785 |
| 23.200 | 0.783 |
| 25.000 | 0.790 |
| 26.900 | 0.806 |
| 28.500 | 0.795 |
| 30.000 | 0.798 |
| 32.000 | 0.803 |
| 34.000 | 0.810 |
| 35.900 | 0.788 |
| 37.700 | 0.758 |
| 39.500 | 0.779 |
| 41.200 | 0.742 |
| 43.300 | 0.735 |
| 44.700 | 0.745 |
| 46.200 | 0.748 |
| 47.700 | 0.736 |
| 49.700 | 0.756 |
| 51.600 | 0.766 |
| 53.500 | 0.733 |
| 54.900 | 0.720 |
| 56.200 | 0.692 |
| 57.600 | 0.736 |
| 59.800 | 0.815 |
| 61.800 | 0.866 |
| 63.800 | 0.942 |
| 66.500 | 0.944 |
| 68.400 | 0.864 |
| 70.100 | 0.801 |
| 71.600 | 0.781 |
| 73.100 | 0.756 |
| 74.600 | 0.696 |
| 76.200 | 0.663 |
| 78.000 | 0.673 |
| 79.500 | 0.696 |
| 81.600 | 0.715 |
| 83.800 | 0.801 |
| 86.000 | 0.849 |
| 88.100 | 0.909 |
| 89.900 | 0.982 |
| 91.500 | 0.993 |
| 95.987 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table C.2. AFACT values for the B-2/shroud 1 COBRA-IV model based on the minimum restriction definition

| AXL[a] | VALUE OF I IS: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.001 | 1.002 | 1.002 | 1.002 | 1.001 | 1.003 | 1.005 | 1.005 | 1.005 | 1.003 |
| 1.800 | 0.974 | 0.960 | 0.960 | 0.960 | 0.974 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 |
| 3.400 | 0.945 | 0.916 | 0.916 | 0.916 | 0.945 | 0.885 | 0.801 | 0.801 | 0.801 | 0.885 |
| 5.000 | 0.947 | 0.919 | 0.919 | 0.919 | 0.947 | 0.889 | 0.808 | 0.808 | 0.808 | 0.889 |
| 6.900 | 0.960 | 0.938 | 0.938 | 0.938 | 0.960 | 0.915 | 0.853 | 0.853 | 0.853 | 0.915 |
| 8.800 | 0.982 | 0.973 | 0.973 | 0.973 | 0.982 | 0.963 | 0.936 | 0.936 | 0.936 | 0.963 |
| 11.500 | 0.982 | 0.972 | 0.972 | 0.972 | 0.982 | 0.961 | 0.933 | 0.933 | 0.933 | 0.961 |
| 13.300 | 0.956 | 0.933 | 0.933 | 0.933 | 0.956 | 0.908 | 0.840 | 0.840 | 0.840 | 0.908 |
| 15.100 | 0.940 | 0.907 | 0.907 | 0.907 | 0.940 | 0.873 | 0.780 | 0.780 | 0.780 | 0.873 |
| 16.800 | 0.924 | 0.882 | 0.882 | 0.882 | 0.924 | 0.839 | 0.721 | 0.721 | 0.721 | 0.839 |
| 18.100 | 0.915 | 0.870 | 0.870 | 0.870 | 0.915 | 0.821 | 0.691 | 0.691 | 0.691 | 0.821 |
| 19.500 | 0.902 | 0.850 | 0.850 | 0.850 | 0.902 | 0.794 | 0.644 | 0.644 | 0.644 | 0.794 |
| 21.400 | 0.908 | 0.858 | 0.858 | 0.858 | 0.908 | 0.806 | 0.664 | 0.664 | 0.664 | 0.806 |
| 23.200 | 0.907 | 0.857 | 0.857 | 0.857 | 0.907 | 0.805 | 0.662 | 0.662 | 0.662 | 0.805 |
| 25.000 | 0.910 | 0.862 | 0.862 | 0.862 | 0.910 | 0.811 | 0.673 | 0.673 | 0.673 | 0.811 |
| 26.900 | 0.917 | 0.872 | 0.872 | 0.872 | 0.917 | 0.825 | 0.697 | 0.697 | 0.697 | 0.825 |
| 28.500 | 0.913 | 0.865 | 0.865 | 0.865 | 0.913 | 0.816 | 0.681 | 0.681 | 0.681 | 0.816 |
| 30.000 | 0.914 | 0.867 | 0.867 | 0.867 | 0.914 | 0.818 | 0.685 | 0.685 | 0.685 | 0.818 |
| 32.000 | 0.916 | 0.871 | 0.871 | 0.871 | 0.916 | 0.823 | 0.693 | 0.693 | 0.693 | 0.823 |
| 34.000 | 0.919 | 0.875 | 0.875 | 0.875 | 0.919 | 0.828 | 0.703 | 0.703 | 0.703 | 0.828 |
| 35.900 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 | 0.809 | 0.669 | 0.669 | 0.669 | 0.809 |
| 37.700 | 0.897 | 0.841 | 0.841 | 0.841 | 0.897 | 0.782 | 0.623 | 0.623 | 0.623 | 0.782 |
| 39.500 | 0.928 | 0.855 | 0.855 | 0.855 | 0.906 | 0.847 | 0.656 | 0.656 | 0.656 | 0.801 |
| 41.200 | 0.916 | 0.830 | 0.830 | 0.830 | 0.890 | 0.821 | 0.597 | 0.597 | 0.597 | 0.767 |
| 43.300 | 0.887 | 0.826 | 0.826 | 0.826 | 0.887 | 0.761 | 0.587 | 0.587 | 0.587 | 0.761 |
| 44.700 | 0.931 | 0.833 | 0.833 | 0.833 | 0.891 | 0.864 | 0.603 | 0.603 | 0.603 | 0.771 |
| 46.200 | 0.931 | 0.834 | 0.834 | 0.834 | 0.892 | 0.865 | 0.607 | 0.607 | 0.607 | 0.773 |
| 47.700 | 0.928 | 0.826 | 0.826 | 0.826 | 0.887 | 0.859 | 0.588 | 0.588 | 0.588 | 0.762 |
| 49.700 | 0.896 | 0.839 | 0.839 | 0.839 | 0.896 | 0.780 | 0.619 | 0.619 | 0.619 | 0.780 |
| 51.600 | 0.900 | 0.846 | 0.846 | 0.846 | 0.900 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 |
| 53.500 | 0.886 | 0.824 | 0.824 | 0.824 | 0.886 | 0.759 | 0.583 | 0.583 | 0.583 | 0.759 |
| 54.900 | 0.881 | 0.816 | 0.816 | 0.816 | 0.881 | 0.748 | 0.564 | 0.564 | 0.564 | 0.748 |
| 56.200 | 0.869 | 0.798 | 0.798 | 0.798 | 0.869 | 0.723 | 0.520 | 0.520 | 0.520 | 0.723 |
| 57.600 | 0.887 | 0.826 | 0.826 | 0.826 | 0.887 | 0.762 | 0.588 | 0.588 | 0.588 | 0.762 |
| 59.800 | 0.921 | 0.878 | 0.878 | 0.878 | 0.921 | 0.833 | 0.711 | 0.711 | 0.711 | 0.833 |
| 61.800 | 0.943 | 0.912 | 0.912 | 0.912 | 0.943 | 0.879 | 0.791 | 0.791 | 0.791 | 0.879 |
| 63.800 | 0.975 | 0.962 | 0.962 | 0.962 | 0.975 | 0.947 | 0.909 | 0.909 | 0.909 | 0.947 |
| 66.500 | 0.976 | 0.963 | 0.963 | 0.963 | 0.976 | 0.950 | 0.913 | 0.913 | 0.913 | 0.950 |
| 68.400 | 0.942 | 0.911 | 0.911 | 0.911 | 0.942 | 0.877 | 0.788 | 0.788 | 0.788 | 0.877 |
| 70.100 | 0.915 | 0.869 | 0.869 | 0.869 | 0.915 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 |
| 71.600 | 0.906 | 0.856 | 0.856 | 0.856 | 0.906 | 0.802 | 0.658 | 0.658 | 0.658 | 0.802 |
| 73.100 | 0.896 | 0.840 | 0.840 | 0.840 | 0.896 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 |
| 74.600 | 0.870 | 0.800 | 0.800 | 0.800 | 0.915 | 0.726 | 0.526 | 0.526 | 0.526 | 0.831 |
| 76.200 | 0.856 | 0.779 | 0.779 | 0.779 | 0.905 | 0.697 | 0.475 | 0.475 | 0.475 | 0.813 |
| 78.000 | 0.860 | 0.785 | 0.785 | 0.785 | 0.908 | 0.705 | 0.490 | 0.490 | 0.490 | 0.819 |
| 79.500 | 0.870 | 0.800 | 0.800 | 0.800 | 0.870 | 0.726 | 0.526 | 0.526 | 0.526 | 0.726 |
| 81.600 | 0.878 | 0.813 | 0.813 | 0.813 | 0.878 | 0.743 | 0.556 | 0.556 | 0.556 | 0.743 |
| 83.800 | 0.915 | 0.869 | 0.869 | 0.869 | 0.915 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 |
| 86.000 | 0.935 | 0.900 | 0.900 | 0.900 | 0.935 | 0.864 | 0.764 | 0.764 | 0.764 | 0.864 |
| 88.100 | 0.961 | 0.940 | 0.940 | 0.940 | 0.961 | 0.918 | 0.858 | 0.858 | 0.858 | 0.918 |
| 89.900 | 0.992 | 0.988 | 0.988 | 0.988 | 0.992 | 0.984 | 0.972 | 0.972 | 0.972 | 0.984 |
| 91.500 | 0.997 | 0.995 | 0.995 | 0.995 | 0.997 | 0.994 | 0.989 | 0.989 | 0.989 | 0.994 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table C.2 (continued)

| AXL[a] | VALUE OF I IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.003 | 1.005 | 1.005 | 1.005 | 1.003 | 1.003 | 1.005 | 1.005 | 1.005 | 1.003 |
| 1.800 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 |
| 3.400 | 0.885 | 0.801 | 0.801 | 0.801 | 0.885 | 0.885 | 0.801 | 0.801 | 0.801 | 0.885 |
| 5.000 | 0.889 | 0.808 | 0.808 | 0.808 | 0.889 | 0.889 | 0.808 | 0.808 | 0.808 | 0.889 |
| 6.900 | 0.915 | 0.853 | 0.853 | 0.853 | 0.915 | 0.915 | 0.853 | 0.853 | 0.853 | 0.915 |
| 8.800 | 0.963 | 0.936 | 0.936 | 0.936 | 0.963 | 0.963 | 0.936 | 0.936 | 0.936 | 0.963 |
| 11.500 | 0.961 | 0.933 | 0.933 | 0.933 | 0.961 | 0.961 | 0.933 | 0.933 | 0.933 | 0.961 |
| 13.300 | 0.908 | 0.840 | 0.840 | 0.840 | 0.908 | 0.908 | 0.840 | 0.840 | 0.840 | 0.908 |
| 15.100 | 0.873 | 0.780 | 0.780 | 0.780 | 0.873 | 0.873 | 0.780 | 0.780 | 0.780 | 0.873 |
| 16.800 | 0.839 | 0.721 | 0.721 | 0.721 | 0.839 | 0.839 | 0.721 | 0.721 | 0.721 | 0.839 |
| 18.100 | 0.821 | 0.691 | 0.691 | 0.691 | 0.821 | 0.821 | 0.691 | 0.691 | 0.691 | 0.821 |
| 19.500 | 0.794 | 0.644 | 0.644 | 0.644 | 0.794 | 0.794 | 0.644 | 0.644 | 0.644 | 0.794 |
| 21.400 | 0.806 | 0.664 | 0.664 | 0.664 | 0.906 | 0.806 | 0.664 | 0.664 | 0.664 | 0.806 |
| 23.200 | 0.805 | 0.662 | 0.662 | 0.662 | 0.805 | 0.805 | 0.662 | 0.662 | 0.662 | 0.805 |
| 25.000 | 0.811 | 0.673 | 0.673 | 0.673 | 0.811 | 0.811 | 0.673 | 0.673 | 0.673 | 0.811 |
| 26.900 | 0.825 | 0.697 | 0.697 | 0.697 | 0.825 | 0.825 | 0.697 | 0.697 | 0.697 | 0.825 |
| 28.500 | 0.816 | 0.681 | 0.681 | 0.681 | 0.816 | 0.816 | 0.681 | 0.681 | 0.681 | 0.816 |
| 30.000 | 0.818 | 0.685 | 0.685 | 0.685 | 0.818 | 0.818 | 0.685 | 0.685 | 0.685 | 0.818 |
| 32.000 | 0.823 | 0.693 | 0.693 | 0.693 | 0.823 | 0.823 | 0.693 | 0.693 | 0.693 | 0.823 |
| 34.000 | 0.828 | 0.703 | 0.703 | 0.703 | 0.828 | 0.828 | 0.703 | 0.703 | 0.703 | 0.828 |
| 35.900 | 0.809 | 0.669 | 0.669 | 0.669 | 0.809 | 0.809 | 0.669 | 0.669 | 0.669 | 0.809 |
| 37.700 | 0.782 | 0.623 | 0.623 | 0.623 | 0.782 | 0.782 | 0.623 | 0.623 | 0.623 | 0.782 |
| 39.500 | 0.801 | 0.656 | 0.656 | 0.656 | 0.801 | 0.801 | 0.656 | 0.656 | 0.656 | 0.801 |
| 41.200 | 0.767 | 0.597 | 0.597 | 0.597 | 0.767 | 0.767 | 0.597 | 0.597 | 0.597 | 0.767 |
| 43.300 | 0.761 | 0.587 | 0.587 | 0.587 | 0.761 | 0.761 | 0.587 | 0.587 | 0.587 | 0.761 |
| 44.700 | 0.822 | 0.603 | 0.603 | 0.603 | 0.771 | 0.771 | 0.603 | 0.603 | 0.603 | 0.771 |
| 46.200 | 0.823 | 0.607 | 0.607 | 0.607 | 0.773 | 0.773 | 0.607 | 0.607 | 0.607 | 0.773 |
| 47.700 | 0.815 | 0.588 | 0.588 | 0.588 | 0.762 | 0.762 | 0.588 | 0.588 | 0.588 | 0.762 |
| 49.700 | 0.780 | 0.619 | 0.619 | 0.619 | 0.780 | 0.780 | 0.619 | 0.619 | 0.619 | 0.780 |
| 51.600 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 |
| 53.500 | 0.759 | 0.583 | 0.583 | 0.583 | 0.759 | 0.759 | 0.583 | 0.583 | 0.583 | 0.759 |
| 54.900 | 0.748 | 0.564 | 0.564 | 0.564 | 0.748 | 0.748 | 0.564 | 0.564 | 0.564 | 0.748 |
| 56.200 | 0.723 | 0.520 | 0.520 | 0.520 | 0.723 | 0.723 | 0.520 | 0.520 | 0.520 | 0.723 |
| 57.600 | 0.762 | 0.588 | 0.588 | 0.588 | 0.762 | 0.762 | 0.588 | 0.588 | 0.588 | 0.762 |
| 59.800 | 0.833 | 0.711 | 0.711 | 0.711 | 0.833 | 0.833 | 0.711 | 0.711 | 0.711 | 0.833 |
| 61.800 | 0.879 | 0.791 | 0.791 | 0.791 | 0.879 | 0.879 | 0.791 | 0.791 | 0.791 | 0.879 |
| 63.800 | 0.947 | 0.909 | 0.909 | 0.909 | 0.947 | 0.947 | 0.909 | 0.909 | 0.909 | 0.947 |
| 66.500 | 0.950 | 0.913 | 0.913 | 0.913 | 0.950 | 0.950 | 0.913 | 0.913 | 0.913 | 0.950 |
| 68.400 | 0.877 | 0.788 | 0.788 | 0.788 | 0.877 | 0.877 | 0.788 | 0.788 | 0.788 | 0.877 |
| 70.100 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 |
| 71.600 | 0.802 | 0.658 | 0.658 | 0.658 | 0.802 | 0.802 | 0.658 | 0.658 | 0.658 | 0.802 |
| 73.100 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 |
| 74.600 | 0.726 | 0.526 | 0.526 | 0.526 | 0.831 | 0.726 | 0.526 | 0.526 | 0.526 | 0.832 |
| 76.200 | 0.697 | 0.475 | 0.475 | 0.475 | 0.813 | 0.697 | 0.475 | 0.475 | 0.475 | 0.814 |
| 78.000 | 0.705 | 0.490 | 0.490 | 0.490 | 0.819 | 0.705 | 0.490 | 0.490 | 0.490 | 0.819 |
| 79.500 | 0.726 | 0.526 | 0.526 | 0.526 | 0.726 | 0.726 | 0.526 | 0.526 | 0.526 | 0.726 |
| 81.600 | 0.743 | 0.556 | 0.556 | 0.556 | 0.743 | 0.743 | 0.556 | 0.556 | 0.556 | 0.743 |
| 83.800 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 |
| 86.000 | 0.864 | 0.764 | 0.764 | 0.764 | 0.864 | 0.864 | 0.764 | 0.764 | 0.764 | 0.864 |
| 88.100 | 0.918 | 0.858 | 0.858 | 0.858 | 0.918 | 0.918 | 0.858 | 0.858 | 0.858 | 0.918 |
| 89.900 | 0.984 | 0.972 | 0.972 | 0.972 | 0.984 | 0.984 | 0.972 | 0.972 | 0.972 | 0.984 |
| 91.500 | 0.994 | 0.989 | 0.989 | 0.989 | 0.994 | 0.994 | 0.989 | 0.989 | 0.989 | 0.994 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table C.2 (continued)

| AXL[a] | VALUE OF I IS: 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.001 | 1.002 | 1.002 | 1.002 | 1.001 |
| 1.800 | 0.974 | 0.960 | 0.960 | 0.960 | 0.974 |
| 3.400 | 0.945 | 0.916 | 0.916 | 0.916 | 0.945 |
| 5.000 | 0.947 | 0.919 | 0.919 | 0.919 | 0.947 |
| 6.900 | 0.960 | 0.938 | 0.938 | 0.938 | 0.960 |
| 8.800 | 0.982 | 0.973 | 0.973 | 0.973 | 0.982 |
| 11.500 | 0.982 | 0.972 | 0.972 | 0.972 | 0.982 |
| 13.300 | 0.956 | 0.933 | 0.933 | 0.933 | 0.956 |
| 15.100 | 0.940 | 0.907 | 0.907 | 0.907 | 0.940 |
| 16.800 | 0.924 | 0.882 | 0.882 | 0.882 | 0.924 |
| 18.100 | 0.915 | 0.870 | 0.870 | 0.870 | 0.915 |
| 19.500 | 0.902 | 0.850 | 0.850 | 0.850 | 0.902 |
| 21.400 | 0.908 | 0.858 | 0.858 | 0.858 | 0.908 |
| 23.200 | 0.907 | 0.857 | 0.857 | 0.857 | 0.907 |
| 25.000 | 0.910 | 0.862 | 0.862 | 0.862 | 0.910 |
| 26.900 | 0.917 | 0.872 | 0.872 | 0.872 | 0.917 |
| 28.500 | 0.913 | 0.865 | 0.865 | 0.865 | 0.913 |
| 30.000 | 0.914 | 0.867 | 0.867 | 0.867 | 0.914 |
| 32.000 | 0.916 | 0.871 | 0.871 | 0.871 | 0.916 |
| 34.000 | 0.919 | 0.875 | 0.875 | 0.875 | 0.919 |
| 35.900 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 |
| 37.700 | 0.897 | 0.841 | 0.841 | 0.841 | 0.897 |
| 39.500 | 0.906 | 0.855 | 0.855 | 0.855 | 0.906 |
| 41.200 | 0.890 | 0.830 | 0.830 | 0.830 | 0.890 |
| 43.300 | 0.887 | 0.826 | 0.826 | 0.826 | 0.887 |
| 44.700 | 0.891 | 0.833 | 0.833 | 0.833 | 0.891 |
| 46.200 | 0.892 | 0.834 | 0.834 | 0.834 | 0.892 |
| 47.700 | 0.887 | 0.826 | 0.826 | 0.826 | 0.887 |
| 49.700 | 0.896 | 0.839 | 0.839 | 0.839 | 0.896 |
| 51.600 | 0.900 | 0.846 | 0.846 | 0.846 | 0.900 |
| 53.500 | 0.886 | 0.824 | 0.824 | 0.824 | 0.886 |
| 54.900 | 0.881 | 0.816 | 0.816 | 0.816 | 0.881 |
| 56.200 | 0.869 | 0.798 | 0.798 | 0.798 | 0.869 |
| 57.600 | 0.887 | 0.826 | 0.826 | 0.826 | 0.887 |
| 59.800 | 0.921 | 0.878 | 0.878 | 0.878 | 0.921 |
| 61.800 | 0.943 | 0.912 | 0.912 | 0.912 | 0.943 |
| 63.800 | 0.975 | 0.962 | 0.962 | 0.962 | 0.975 |
| 66.500 | 0.976 | 0.963 | 0.963 | 0.963 | 0.976 |
| 68.400 | 0.942 | 0.911 | 0.911 | 0.911 | 0.942 |
| 70.100 | 0.915 | 0.869 | 0.869 | 0.869 | 0.915 |
| 71.600 | 0.906 | 0.856 | 0.856 | 0.856 | 0.906 |
| 73.100 | 0.896 | 0.840 | 0.840 | 0.840 | 0.896 |
| 74.600 | 0.870 | 0.800 | 0.800 | 0.800 | 0.870 |
| 76.200 | 0.856 | 0.779 | 0.779 | 0.779 | 0.856 |
| 78.000 | 0.860 | 0.785 | 0.785 | 0.785 | 0.860 |
| 79.500 | 0.870 | 0.800 | 0.800 | 0.800 | 0.870 |
| 81.600 | 0.878 | 0.813 | 0.813 | 0.813 | 0.878 |
| 83.800 | 0.915 | 0.869 | 0.869 | 0.869 | 0.915 |
| 86.000 | 0.935 | 0.900 | 0.900 | 0.900 | 0.935 |
| 88.100 | 0.961 | 0.940 | 0.940 | 0.940 | 0.961 |
| 89.900 | 0.992 | 0.988 | 0.988 | 0.988 | 0.992 |
| 91.500 | 0.997 | 0.995 | 0.995 | 0.995 | 0.997 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table C.3. GFACT values for the B-2/shroud 1 COBRA-IV model based on the minimum restriction definition

| GAPXL[a] VALUE OF K IS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.002 | 1.004 | 1.002 | 1.010 | 1.002 | 1.010 | 1.002 | 1.010 | 1.004 | 1.004 |
| 1.800 | 0.958 | 0.934 | 0.958 | 0.826 | 0.958 | 0.826 | 0.958 | 0.826 | 0.934 | 0.934 |
| 3.400 | 0.913 | 0.865 | 0.913 | 0.642 | 0.913 | 0.642 | 0.913 | 0.642 | 0.865 | 0.865 |
| 5.000 | 0.916 | 0.869 | 0.916 | 0.654 | 0.916 | 0.654 | 0.916 | 0.654 | 0.869 | 0.869 |
| 6.900 | 0.935 | 0.899 | 0.935 | 0.732 | 0.935 | 0.732 | 0.935 | 0.732 | 0.899 | 0.899 |
| 8.800 | 0.971 | 0.955 | 0.971 | 0.880 | 0.971 | 0.880 | 0.971 | 0.880 | 0.955 | 0.955 |
| 11.500 | 0.970 | 0.953 | 0.970 | 0.875 | 0.970 | 0.875 | 0.970 | 0.875 | 0.953 | 0.953 |
| 13.300 | 0.929 | 0.890 | 0.929 | 0.709 | 0.929 | 0.709 | 0.929 | 0.709 | 0.890 | 0.890 |
| 15.100 | 0.904 | 0.852 | 0.904 | 0.606 | 0.904 | 0.606 | 0.904 | 0.606 | 0.852 | 0.852 |
| 16.800 | 0.880 | 0.814 | 0.880 | 0.508 | 0.880 | 0.508 | 0.880 | 0.508 | 0.814 | 0.814 |
| 18.100 | 0.868 | 0.796 | 0.868 | 0.459 | 0.868 | 0.459 | 0.868 | 0.459 | 0.796 | 0.796 |
| 19.500 | 0.850 | 0.768 | 0.850 | 0.383 | 0.850 | 0.383 | 0.850 | 0.383 | 0.768 | 0.768 |
| 21.400 | 0.857 | 0.780 | 0.857 | 0.415 | 0.857 | 0.415 | 0.857 | 0.415 | 0.780 | 0.780 |
| 23.200 | 0.857 | 0.778 | 0.857 | 0.412 | 0.857 | 0.412 | 0.857 | 0.412 | 0.778 | 0.778 |
| 25.000 | 0.861 | 0.785 | 0.861 | 0.430 | 0.861 | 0.430 | 0.861 | 0.430 | 0.785 | 0.785 |
| 26.900 | 0.870 | 0.800 | 0.870 | 0.469 | 0.870 | 0.469 | 0.870 | 0.469 | 0.800 | 0.800 |
| 28.500 | 0.864 | 0.790 | 0.864 | 0.443 | 0.864 | 0.443 | 0.864 | 0.443 | 0.790 | 0.790 |
| 30.000 | 0.866 | 0.792 | 0.866 | 0.449 | 0.866 | 0.449 | 0.866 | 0.449 | 0.792 | 0.792 |
| 32.000 | 0.869 | 0.797 | 0.869 | 0.462 | 0.869 | 0.462 | 0.869 | 0.462 | 0.797 | 0.797 |
| 34.000 | 0.873 | 0.803 | 0.873 | 0.478 | 0.873 | 0.478 | 0.873 | 0.478 | 0.803 | 0.803 |
| 35.900 | 0.859 | 0.783 | 0.859 | 0.423 | 0.859 | 0.423 | 0.859 | 0.423 | 0.783 | 0.783 |
| 37.700 | 0.842 | 0.755 | 0.842 | 0.350 | 0.842 | 0.350 | 0.842 | 0.350 | 0.755 | 0.755 |
| 39.500 | 0.854 | 0.775 | 0.854 | 0.403 | 0.854 | 0.403 | 0.854 | 0.403 | 0.775 | 0.775 |
| 41.200 | 0.832 | 0.740 | 0.832 | 0.310 | 0.832 | 0.310 | 0.832 | 0.310 | 0.740 | 0.740 |
| 43.300 | 0.828 | 0.734 | 0.828 | 0.294 | 0.828 | 0.294 | 0.828 | 0.294 | 0.734 | 0.734 |
| 44.700 | 0.834 | 0.743 | 0.834 | 0.319 | 0.834 | 0.319 | 0.834 | 0.319 | 0.743 | 0.743 |
| 46.200 | 0.835 | 0.746 | 0.835 | 0.325 | 0.835 | 0.325 | 0.835 | 0.325 | 0.746 | 0.746 |
| 47.700 | 0.828 | 0.734 | 0.828 | 0.296 | 0.828 | 0.296 | 0.828 | 0.296 | 0.734 | 0.734 |
| 49.700 | 0.840 | 0.753 | 0.840 | 0.344 | 0.840 | 0.344 | 0.840 | 0.344 | 0.753 | 0.753 |
| 51.600 | 0.846 | 0.762 | 0.846 | 0.369 | 0.846 | 0.369 | 0.846 | 0.369 | 0.762 | 0.762 |
| 53.500 | 0.826 | 0.731 | 0.826 | 0.288 | 0.826 | 0.288 | 0.826 | 0.288 | 0.731 | 0.731 |
| 54.900 | 0.819 | 0.720 | 0.819 | 0.258 | 0.819 | 0.258 | 0.819 | 0.258 | 0.720 | 0.720 |
| 56.200 | 0.803 | 0.695 | 0.803 | 0.191 | 0.803 | 0.191 | 0.803 | 0.191 | 0.695 | 0.695 |
| 57.600 | 0.828 | 0.734 | 0.828 | 0.296 | 0.828 | 0.296 | 0.828 | 0.296 | 0.734 | 0.734 |
| 59.800 | 0.876 | 0.808 | 0.876 | 0.491 | 0.876 | 0.491 | 0.876 | 0.491 | 0.808 | 0.808 |
| 61.800 | 0.909 | 0.859 | 0.909 | 0.625 | 0.909 | 0.625 | 0.909 | 0.625 | 0.859 | 0.859 |
| 63.800 | 0.959 | 0.936 | 0.959 | 0.831 | 0.959 | 0.831 | 0.959 | 0.831 | 0.936 | 0.936 |
| 66.500 | 0.961 | 0.939 | 0.961 | 0.839 | 0.961 | 0.839 | 0.961 | 0.839 | 0.939 | 0.939 |
| 68.400 | 0.907 | 0.857 | 0.907 | 0.620 | 0.907 | 0.620 | 0.907 | 0.620 | 0.857 | 0.857 |
| 70.100 | 0.868 | 0.795 | 0.868 | 0.457 | 0.868 | 0.457 | 0.868 | 0.457 | 0.795 | 0.795 |
| 71.600 | 0.855 | 0.776 | 0.855 | 0.406 | 0.855 | 0.406 | 0.855 | 0.406 | 0.776 | 0.776 |
| 73.100 | 0.840 | 0.753 | 0.840 | 0.346 | 0.840 | 0.346 | 0.840 | 0.346 | 0.753 | 0.753 |
| 74.600 | 0.805 | 0.699 | 0.805 | 0.200 | 0.805 | 0.200 | 0.805 | 0.200 | 0.699 | 0.699 |
| 76.200 | 0.786 | 0.670 | 0.786 | 0.124 | 0.786 | 0.124 | 0.786 | 0.124 | 0.670 | 0.670 |
| 78.000 | 0.792 | 0.678 | 0.792 | 0.146 | 0.792 | 0.146 | 0.792 | 0.146 | 0.678 | 0.678 |
| 79.500 | 0.805 | 0.699 | 0.805 | 0.200 | 0.805 | 0.200 | 0.805 | 0.200 | 0.699 | 0.699 |
| 81.600 | 0.816 | 0.716 | 0.816 | 0.246 | 0.816 | 0.246 | 0.816 | 0.246 | 0.716 | 0.716 |
| 83.800 | 0.868 | 0.795 | 0.868 | 0.457 | 0.868 | 0.457 | 0.868 | 0.457 | 0.795 | 0.795 |
| 86.000 | 0.897 | 0.841 | 0.897 | 0.579 | 0.897 | 0.579 | 0.897 | 0.579 | 0.841 | 0.841 |
| 88.100 | 0.937 | 0.902 | 0.937 | 0.741 | 0.937 | 0.741 | 0.937 | 0.741 | 0.902 | 0.902 |
| 89.900 | 0.987 | 0.980 | 0.987 | 0.947 | 0.987 | 0.947 | 0.987 | 0.947 | 0.980 | 0.980 |
| 91.500 | 0.995 | 0.992 | 0.995 | 0.979 | 0.995 | 0.979 | 0.995 | 0.979 | 0.992 | 0.992 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table C.3 (continued)

| GAPXL[a] | VALUE OF K IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.004 | 1.004 | 1.010 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.934 | 0.826 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.865 | 0.865 | 0.642 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.869 | 0.869 | 0.654 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.899 | 0.899 | 0.732 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.955 | 0.955 | 0.880 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.953 | 0.953 | 0.875 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.890 | 0.890 | 0.709 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.852 | 0.852 | 0.606 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.814 | 0.814 | 0.508 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.796 | 0.796 | 0.459 |
| 19.500 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.768 | 0.768 | 0.383 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.780 | 0.780 | 0.415 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.778 | 0.778 | 0.412 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.785 | 0.785 | 0.430 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.800 | 0.800 | 0.469 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.790 | 0.790 | 0.443 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.792 | 0.792 | 0.449 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.797 | 0.797 | 0.462 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.803 | 0.803 | 0.478 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.783 | 0.783 | 0.423 |
| 37.700 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.755 | 0.755 | 0.350 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.775 | 0.403 |
| 41.200 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.740 | 0.740 | 0.310 |
| 43.300 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.734 | 0.734 | 0.294 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.743 | 0.743 | 0.319 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.746 | 0.746 | 0.325 |
| 47.700 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.734 | 0.296 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.753 | 0.753 | 0.344 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.762 | 0.369 |
| 53.500 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.731 | 0.731 | 0.288 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.720 | 0.720 | 0.258 |
| 56.200 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.695 | 0.695 | 0.191 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.734 | 0.296 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.808 | 0.808 | 0.491 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.859 | 0.859 | 0.625 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.936 | 0.936 | 0.831 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.939 | 0.939 | 0.839 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.857 | 0.857 | 0.620 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.795 | 0.457 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.776 | 0.776 | 0.406 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.753 | 0.346 |
| 74.600 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.699 | 0.699 | 0.200 |
| 76.200 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.670 | 0.670 | 0.124 |
| 78.000 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.678 | 0.678 | 0.146 |
| 79.500 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.699 | 0.699 | 0.200 |
| 81.600 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.716 | 0.716 | 0.246 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.795 | 0.457 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.841 | 0.841 | 0.579 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.902 | 0.902 | 0.741 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.980 | 0.980 | 0.947 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.992 | 0.992 | 0.979 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table C.3 (continued)

| GAPXL[a] | VALUE OF K IS: 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.004 | 1.004 | 1.010 | 1.010 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.934 | 0.826 | 0.826 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.865 | 0.865 | 0.642 | 0.642 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.869 | 0.869 | 0.654 | 0.654 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.899 | 0.899 | 0.732 | 0.732 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.955 | 0.955 | 0.880 | 0.880 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.953 | 0.953 | 0.875 | 0.875 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.890 | 0.890 | 0.709 | 0.709 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.852 | 0.852 | 0.606 | 0.606 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.814 | 0.814 | 0.508 | 0.508 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.796 | 0.796 | 0.459 | 0.459 |
| 19.500 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.768 | 0.768 | 0.383 | 0.383 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.780 | 0.780 | 0.415 | 0.415 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.778 | 0.778 | 0.412 | 0.412 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.785 | 0.785 | 0.430 | 0.430 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.800 | 0.800 | 0.469 | 0.469 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.790 | 0.790 | 0.443 | 0.443 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.792 | 0.792 | 0.449 | 0.449 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.797 | 0.797 | 0.462 | 0.462 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.803 | 0.803 | 0.478 | 0.478 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.783 | 0.783 | 0.423 | 0.423 |
| 37.700 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.755 | 0.755 | 0.350 | 0.350 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.775 | 0.403 | 0.403 |
| 41.200 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.740 | 0.740 | 0.310 | 0.310 |
| 43.300 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.734 | 0.734 | 0.294 | 0.294 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.743 | 0.743 | 0.319 | 0.319 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.746 | 0.746 | 0.325 | 0.325 |
| 47.700 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.734 | 0.296 | 0.296 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.753 | 0.753 | 0.344 | 0.344 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.762 | 0.369 | 0.369 |
| 53.500 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.731 | 0.731 | 0.288 | 0.288 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.720 | 0.720 | 0.258 | 0.258 |
| 56.200 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.695 | 0.695 | 0.191 | 0.191 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.734 | 0.296 | 0.296 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.808 | 0.808 | 0.491 | 0.491 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.859 | 0.859 | 0.625 | 0.625 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.936 | 0.936 | 0.831 | 0.831 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.939 | 0.939 | 0.839 | 0.839 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.857 | 0.857 | 0.620 | 0.620 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.795 | 0.457 | 0.457 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.776 | 0.776 | 0.406 | 0.406 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.753 | 0.346 | 0.346 |
| 74.600 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.699 | 0.699 | 0.200 | 0.200 |
| 76.200 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.670 | 0.670 | 0.124 | 0.124 |
| 78.000 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.678 | 0.678 | 0.146 | 0.146 |
| 79.500 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.699 | 0.699 | 0.200 | 0.200 |
| 81.600 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.716 | 0.716 | 0.246 | 0.246 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.795 | 0.457 | 0.457 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.841 | 0.841 | 0.579 | 0.579 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.902 | 0.902 | 0.741 | 0.741 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.980 | 0.980 | 0.947 | 0.947 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.992 | 0.992 | 0.979 | 0.979 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table C.3 (continued)

| GAPXL[a] | VALUE OF K IS: 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.004 | 1.002 | 1.002 | 1.002 | 1.002 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.958 | 0.958 | 0.958 | 0.958 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.865 | 0.913 | 0.913 | 0.913 | 0.913 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.869 | 0.916 | 0.916 | 0.916 | 0.916 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.899 | 0.935 | 0.935 | 0.935 | 0.935 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.955 | 0.971 | 0.971 | 0.971 | 0.971 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.953 | 0.970 | 0.970 | 0.970 | 0.970 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.890 | 0.929 | 0.929 | 0.929 | 0.929 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.852 | 0.904 | 0.904 | 0.904 | 0.904 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.814 | 0.880 | 0.880 | 0.880 | 0.880 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.796 | 0.868 | 0.868 | 0.868 | 0.868 |
| 19.500 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.768 | 0.850 | 0.850 | 0.850 | 0.850 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.780 | 0.857 | 0.857 | 0.857 | 0.857 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.773 | 0.857 | 0.857 | 0.857 | 0.857 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.785 | 0.861 | 0.861 | 0.861 | 0.861 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.800 | 0.870 | 0.870 | 0.870 | 0.870 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.790 | 0.864 | 0.864 | 0.864 | 0.864 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.792 | 0.866 | 0.866 | 0.866 | 0.866 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.797 | 0.869 | 0.869 | 0.869 | 0.869 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.803 | 0.873 | 0.873 | 0.873 | 0.873 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.783 | 0.859 | 0.859 | 0.859 | 0.859 |
| 37.700 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.755 | 0.842 | 0.842 | 0.842 | 0.842 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.854 | 0.854 | 0.854 | 0.854 |
| 41.200 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.740 | 0.832 | 0.832 | 0.832 | 0.832 |
| 43.300 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.734 | 0.828 | 0.828 | 0.828 | 0.828 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.743 | 0.834 | 0.834 | 0.834 | 0.834 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.746 | 0.835 | 0.835 | 0.835 | 0.835 |
| 47.700 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.828 | 0.828 | 0.828 | 0.828 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.753 | 0.840 | 0.840 | 0.840 | 0.840 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.846 | 0.846 | 0.846 | 0.846 |
| 53.500 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.731 | 0.826 | 0.826 | 0.826 | 0.826 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.720 | 0.819 | 0.819 | 0.819 | 0.819 |
| 56.200 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.695 | 0.803 | 0.803 | 0.803 | 0.803 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.828 | 0.828 | 0.828 | 0.828 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.808 | 0.876 | 0.876 | 0.876 | 0.876 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.859 | 0.909 | 0.909 | 0.909 | 0.909 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.936 | 0.959 | 0.959 | 0.959 | 0.959 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.939 | 0.961 | 0.961 | 0.961 | 0.961 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.857 | 0.907 | 0.907 | 0.907 | 0.907 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.868 | 0.868 | 0.868 | 0.868 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.776 | 0.855 | 0.855 | 0.855 | 0.855 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.840 | 0.840 | 0.840 | 0.840 |
| 74.600 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.699 | 0.805 | 0.805 | 0.805 | 0.805 |
| 76.200 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.670 | 0.786 | 0.786 | 0.786 | 0.786 |
| 78.000 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.678 | 0.792 | 0.792 | 0.792 | 0.792 |
| 79.500 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.699 | 0.805 | 0.805 | 0.805 | 0.805 |
| 81.600 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.716 | 0.816 | 0.816 | 0.816 | 0.816 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.868 | 0.868 | 0.868 | 0.868 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.841 | 0.897 | 0.897 | 0.897 | 0.897 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.902 | 0.937 | 0.937 | 0.937 | 0.937 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.980 | 0.987 | 0.987 | 0.987 | 0.987 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.992 | 0.995 | 0.995 | 0.995 | 0.995 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]GAPXL values are the centimeters from the bottom of the heated zone.

# Appendix D

## B-2/SHROUD 1 BUNDLE-AVERAGED GEOMETRY DATA, MAXIMUM RESTRICTION DEFINITION

The data in Appendix D represent the input from card groups 5 and 6 as required by ref. 2 for the B-2/shroud 1 COBRA-IV model based on the maximum restriction definition.

Table D.1. Shroud flow area reductions for the B-2/shroud 1 COBRA-IV model based on the maximum restriction definition

| AXL[a] | FRACTIONAL SHROUD FLOW AREA |
|---|---|
| -47.676 | 1.000 |
| 0.000 | 1.003 |
| 1.800 | 0.940 |
| 3.400 | 0.872 |
| 5.000 | 0.877 |
| 6.900 | 0.906 |
| 8.800 | 0.959 |
| 11.500 | 0.957 |
| 13.300 | 0.897 |
| 15.100 | 0.859 |
| 16.800 | 0.821 |
| 18.100 | 0.802 |
| 19.500 | 0.756 |
| 21.400 | 0.785 |
| 23.200 | 0.783 |
| 25.000 | 0.790 |
| 26.900 | 0.806 |
| 28.500 | 0.795 |
| 30.000 | 0.798 |
| 32.000 | 0.803 |
| 34.000 | 0.810 |
| 35.900 | 0.788 |
| 37.700 | 0.752 |
| 39.500 | 0.779 |
| 41.200 | 0.718 |
| 43.300 | 0.706 |
| 44.700 | 0.745 |
| 46.200 | 0.748 |
| 47.700 | 0.724 |
| 49.700 | 0.756 |
| 51.600 | 0.766 |
| 53.500 | 0.701 |
| 54.900 | 0.720 |
| 56.200 | 0.640 |
| 57.600 | 0.736 |
| 59.800 | 0.815 |
| 61.800 | 0.866 |
| 63.800 | 0.942 |
| 66.500 | 0.944 |
| 68.400 | 0.864 |
| 70.100 | 0.801 |
| 71.600 | 0.781 |
| 73.100 | 0.756 |
| 74.600 | 0.686 |
| 76.200 | 0.592 |
| 78.000 | 0.657 |
| 79.500 | 0.690 |
| 81.600 | 0.676 |
| 83.800 | 0.801 |
| 86.000 | 0.849 |
| 88.100 | 0.909 |
| 89.900 | 0.982 |
| 91.500 | 0.993 |
| 95.987 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table D.2. AFACT values for the B-2/shroud 1 COBRA-IV model based on the maximum restriction definition

| AXL[a] | VALUE OF I IS: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.001 | 1.002 | 1.002 | 1.002 | 1.001 | 1.003 | 1.005 | 1.005 | 1.005 | 1.003 |
| 1.800 | 0.974 | 0.960 | 0.960 | 0.960 | 0.974 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 |
| 3.400 | 0.945 | 0.916 | 0.916 | 0.916 | 0.945 | 0.885 | 0.801 | 0.801 | 0.801 | 0.885 |
| 5.000 | 0.947 | 0.919 | 0.919 | 0.919 | 0.947 | 0.889 | 0.808 | 0.808 | 0.808 | 0.889 |
| 6.900 | 0.960 | 0.938 | 0.938 | 0.938 | 0.960 | 0.915 | 0.853 | 0.853 | 0.853 | 0.915 |
| 8.800 | 0.982 | 0.973 | 0.973 | 0.973 | 0.982 | 0.963 | 0.936 | 0.936 | 0.936 | 0.963 |
| 11.500 | 0.982 | 0.972 | 0.972 | 0.972 | 0.982 | 0.961 | 0.933 | 0.933 | 0.933 | 0.961 |
| 13.300 | 0.956 | 0.933 | 0.933 | 0.933 | 0.956 | 0.908 | 0.840 | 0.840 | 0.840 | 0.908 |
| 15.100 | 0.940 | 0.907 | 0.907 | 0.907 | 0.940 | 0.873 | 0.780 | 0.780 | 0.780 | 0.873 |
| 16.800 | 0.924 | 0.882 | 0.882 | 0.882 | 0.924 | 0.839 | 0.721 | 0.721 | 0.721 | 0.839 |
| 18.100 | 0.915 | 0.870 | 0.870 | 0.870 | 0.915 | 0.821 | 0.691 | 0.691 | 0.691 | 0.821 |
| 19.500 | 0.896 | 0.840 | 0.840 | 0.840 | 0.896 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 |
| 21.400 | 0.908 | 0.858 | 0.858 | 0.858 | 0.908 | 0.806 | 0.664 | 0.664 | 0.664 | 0.806 |
| 23.200 | 0.907 | 0.857 | 0.857 | 0.857 | 0.907 | 0.805 | 0.662 | 0.662 | 0.662 | 0.805 |
| 25.000 | 0.910 | 0.862 | 0.862 | 0.862 | 0.910 | 0.811 | 0.673 | 0.673 | 0.673 | 0.811 |
| 26.900 | 0.917 | 0.872 | 0.872 | 0.872 | 0.917 | 0.825 | 0.697 | 0.697 | 0.697 | 0.825 |
| 28.500 | 0.913 | 0.865 | 0.865 | 0.865 | 0.913 | 0.816 | 0.681 | 0.681 | 0.681 | 0.816 |
| 30.000 | 0.914 | 0.867 | 0.867 | 0.867 | 0.914 | 0.818 | 0.685 | 0.685 | 0.685 | 0.818 |
| 32.000 | 0.916 | 0.871 | 0.871 | 0.871 | 0.916 | 0.823 | 0.693 | 0.693 | 0.693 | 0.823 |
| 34.000 | 0.919 | 0.875 | 0.875 | 0.875 | 0.919 | 0.828 | 0.703 | 0.703 | 0.703 | 0.828 |
| 35.900 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 | 0.809 | 0.669 | 0.669 | 0.669 | 0.809 |
| 37.700 | 0.894 | 0.837 | 0.837 | 0.837 | 0.894 | 0.777 | 0.614 | 0.614 | 0.614 | 0.777 |
| 39.500 | 0.928 | 0.855 | 0.855 | 0.855 | 0.906 | 0.847 | 0.656 | 0.656 | 0.656 | 0.801 |
| 41.200 | 0.909 | 0.815 | 0.815 | 0.815 | 0.880 | 0.805 | 0.561 | 0.561 | 0.561 | 0.746 |
| 43.300 | 0.875 | 0.807 | 0.807 | 0.807 | 0.875 | 0.735 | 0.542 | 0.542 | 0.542 | 0.735 |
| 44.700 | 0.931 | 0.833 | 0.833 | 0.833 | 0.891 | 0.864 | 0.603 | 0.603 | 0.603 | 0.771 |
| 46.200 | 0.931 | 0.834 | 0.834 | 0.834 | 0.892 | 0.865 | 0.607 | 0.607 | 0.607 | 0.773 |
| 47.700 | 0.925 | 0.818 | 0.818 | 0.818 | 0.882 | 0.852 | 0.569 | 0.569 | 0.569 | 0.751 |
| 49.700 | 0.896 | 0.839 | 0.839 | 0.839 | 0.896 | 0.780 | 0.619 | 0.619 | 0.619 | 0.780 |
| 51.600 | 0.900 | 0.846 | 0.846 | 0.846 | 0.900 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 |
| 53.500 | 0.872 | 0.803 | 0.803 | 0.803 | 0.872 | 0.731 | 0.534 | 0.534 | 0.534 | 0.731 |
| 54.900 | 0.881 | 0.816 | 0.816 | 0.816 | 0.881 | 0.748 | 0.564 | 0.564 | 0.564 | 0.748 |
| 56.200 | 0.846 | 0.763 | 0.763 | 0.763 | 0.846 | 0.675 | 0.438 | 0.438 | 0.438 | 0.675 |
| 57.600 | 0.887 | 0.826 | 0.826 | 0.826 | 0.887 | 0.762 | 0.588 | 0.588 | 0.588 | 0.762 |
| 59.800 | 0.921 | 0.878 | 0.878 | 0.878 | 0.921 | 0.833 | 0.711 | 0.711 | 0.711 | 0.833 |
| 61.800 | 0.943 | 0.912 | 0.912 | 0.912 | 0.943 | 0.879 | 0.791 | 0.791 | 0.791 | 0.879 |
| 63.800 | 0.975 | 0.962 | 0.962 | 0.962 | 0.975 | 0.947 | 0.909 | 0.909 | 0.909 | 0.947 |
| 66.500 | 0.976 | 0.963 | 0.963 | 0.963 | 0.976 | 0.950 | 0.913 | 0.913 | 0.913 | 0.950 |
| 68.400 | 0.942 | 0.911 | 0.911 | 0.911 | 0.942 | 0.877 | 0.788 | 0.788 | 0.788 | 0.877 |
| 70.100 | 0.915 | 0.869 | 0.869 | 0.869 | 0.915 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 |
| 71.600 | 0.906 | 0.856 | 0.856 | 0.856 | 0.906 | 0.802 | 0.658 | 0.658 | 0.658 | 0.802 |
| 73.100 | 0.896 | 0.840 | 0.840 | 0.840 | 0.896 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 |
| 74.600 | 0.866 | 0.794 | 0.794 | 0.794 | 0.912 | 0.717 | 0.511 | 0.511 | 0.511 | 0.826 |
| 76.200 | 0.826 | 0.732 | 0.732 | 0.732 | 0.885 | 0.632 | 0.364 | 0.364 | 0.364 | 0.774 |
| 78.000 | 0.853 | 0.774 | 0.774 | 0.774 | 0.904 | 0.691 | 0.465 | 0.465 | 0.465 | 0.810 |
| 79.500 | 0.867 | 0.796 | 0.796 | 0.796 | 0.867 | 0.720 | 0.516 | 0.516 | 0.516 | 0.720 |
| 81.600 | 0.861 | 0.787 | 0.787 | 0.787 | 0.861 | 0.708 | 0.494 | 0.494 | 0.494 | 0.708 |
| 83.800 | 0.915 | 0.869 | 0.869 | 0.869 | 0.915 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 |
| 86.000 | 0.935 | 0.900 | 0.900 | 0.900 | 0.935 | 0.864 | 0.764 | 0.764 | 0.764 | 0.864 |
| 88.100 | 0.961 | 0.940 | 0.940 | 0.940 | 0.961 | 0.918 | 0.858 | 0.858 | 0.858 | 0.918 |
| 89.900 | 0.992 | 0.988 | 0.988 | 0.988 | 0.992 | 0.984 | 0.972 | 0.972 | 0.972 | 0.984 |
| 91.500 | 0.997 | 0.995 | 0.995 | 0.995 | 0.997 | 0.994 | 0.989 | 0.989 | 0.989 | 0.994 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table D.2 (continued)

| AXL[a] | VALUE OF I IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.003 | 1.005 | 1.005 | 1.005 | 1.003 | 1.003 | 1.005 | 1.005 | 1.005 | 1.003 |
| 1.800 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 | 0.946 | 0.906 | 0.906 | 0.906 | 0.946 |
| 3.400 | 0.885 | 0.801 | 0.801 | 0.801 | 0.885 | 0.885 | 0.801 | 0.801 | 0.801 | 0.885 |
| 5.000 | 0.889 | 0.808 | 0.808 | 0.808 | 0.889 | 0.889 | 0.808 | 0.808 | 0.808 | 0.889 |
| 6.900 | 0.915 | 0.853 | 0.853 | 0.853 | 0.915 | 0.915 | 0.853 | 0.853 | 0.853 | 0.915 |
| 8.800 | 0.963 | 0.936 | 0.936 | 0.936 | 0.963 | 0.963 | 0.936 | 0.936 | 0.936 | 0.963 |
| 11.500 | 0.961 | 0.933 | 0.933 | 0.933 | 0.961 | 0.961 | 0.933 | 0.933 | 0.933 | 0.961 |
| 13.300 | 0.908 | 0.840 | 0.840 | 0.840 | 0.908 | 0.908 | 0.840 | 0.840 | 0.840 | 0.908 |
| 15.100 | 0.873 | 0.780 | 0.780 | 0.780 | 0.873 | 0.873 | 0.780 | 0.780 | 0.780 | 0.873 |
| 16.800 | 0.839 | 0.721 | 0.721 | 0.721 | 0.839 | 0.839 | 0.721 | 0.721 | 0.721 | 0.839 |
| 18.100 | 0.821 | 0.691 | 0.691 | 0.691 | 0.821 | 0.821 | 0.691 | 0.691 | 0.691 | 0.821 |
| 19.500 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 |
| 21.400 | 0.806 | 0.664 | 0.664 | 0.664 | 0.806 | 0.806 | 0.664 | 0.664 | 0.664 | 0.806 |
| 23.200 | 0.805 | 0.662 | 0.662 | 0.662 | 0.805 | 0.805 | 0.662 | 0.662 | 0.662 | 0.805 |
| 25.000 | 0.811 | 0.673 | 0.673 | 0.673 | 0.811 | 0.811 | 0.673 | 0.673 | 0.673 | 0.811 |
| 26.900 | 0.825 | 0.697 | 0.697 | 0.697 | 0.825 | 0.825 | 0.697 | 0.697 | 0.697 | 0.825 |
| 28.500 | 0.816 | 0.681 | 0.681 | 0.681 | 0.816 | 0.816 | 0.681 | 0.681 | 0.681 | 0.816 |
| 30.000 | 0.818 | 0.685 | 0.685 | 0.685 | 0.818 | 0.818 | 0.685 | 0.685 | 0.685 | 0.818 |
| 32.000 | 0.823 | 0.693 | 0.693 | 0.693 | 0.823 | 0.823 | 0.693 | 0.693 | 0.693 | 0.823 |
| 34.000 | 0.828 | 0.703 | 0.703 | 0.703 | 0.828 | 0.828 | 0.703 | 0.703 | 0.703 | 0.828 |
| 35.900 | 0.809 | 0.669 | 0.669 | 0.669 | 0.809 | 0.809 | 0.669 | 0.669 | 0.669 | 0.809 |
| 37.700 | 0.777 | 0.614 | 0.614 | 0.614 | 0.777 | 0.777 | 0.614 | 0.614 | 0.614 | 0.777 |
| 39.500 | 0.801 | 0.656 | 0.656 | 0.656 | 0.801 | 0.801 | 0.656 | 0.656 | 0.656 | 0.801 |
| 41.200 | 0.746 | 0.561 | 0.561 | 0.561 | 0.746 | 0.746 | 0.561 | 0.561 | 0.561 | 0.746 |
| 43.300 | 0.735 | 0.542 | 0.542 | 0.542 | 0.735 | 0.735 | 0.542 | 0.542 | 0.542 | 0.735 |
| 44.700 | 0.822 | 0.603 | 0.603 | 0.603 | 0.771 | 0.771 | 0.603 | 0.603 | 0.603 | 0.771 |
| 46.200 | 0.823 | 0.607 | 0.607 | 0.607 | 0.773 | 0.773 | 0.607 | 0.607 | 0.607 | 0.773 |
| 47.700 | 0.806 | 0.569 | 0.569 | 0.569 | 0.751 | 0.751 | 0.569 | 0.569 | 0.569 | 0.751 |
| 49.700 | 0.780 | 0.619 | 0.619 | 0.619 | 0.780 | 0.780 | 0.619 | 0.619 | 0.619 | 0.780 |
| 51.600 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 | 0.789 | 0.635 | 0.635 | 0.635 | 0.789 |
| 53.500 | 0.731 | 0.534 | 0.534 | 0.534 | 0.731 | 0.731 | 0.534 | 0.534 | 0.534 | 0.731 |
| 54.900 | 0.748 | 0.564 | 0.564 | 0.564 | 0.748 | 0.748 | 0.564 | 0.564 | 0.564 | 0.748 |
| 56.200 | 0.675 | 0.438 | 0.438 | 0.438 | 0.675 | 0.675 | 0.438 | 0.438 | 0.438 | 0.675 |
| 57.600 | 0.762 | 0.588 | 0.588 | 0.588 | 0.762 | 0.762 | 0.588 | 0.588 | 0.588 | 0.762 |
| 59.800 | 0.833 | 0.711 | 0.711 | 0.711 | 0.833 | 0.833 | 0.711 | 0.711 | 0.711 | 0.833 |
| 61.800 | 0.879 | 0.791 | 0.791 | 0.791 | 0.879 | 0.879 | 0.791 | 0.791 | 0.791 | 0.879 |
| 63.800 | 0.947 | 0.909 | 0.909 | 0.909 | 0.947 | 0.947 | 0.909 | 0.909 | 0.909 | 0.947 |
| 66.500 | 0.950 | 0.913 | 0.913 | 0.913 | 0.950 | 0.950 | 0.913 | 0.913 | 0.913 | 0.950 |
| 68.400 | 0.877 | 0.788 | 0.788 | 0.788 | 0.877 | 0.877 | 0.788 | 0.788 | 0.788 | 0.877 |
| 70.100 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 |
| 71.600 | 0.802 | 0.658 | 0.658 | 0.658 | 0.802 | 0.802 | 0.658 | 0.658 | 0.658 | 0.802 |
| 73.100 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 | 0.780 | 0.620 | 0.620 | 0.620 | 0.780 |
| 74.600 | 0.717 | 0.511 | 0.511 | 0.511 | 0.826 | 0.717 | 0.511 | 0.511 | 0.511 | 0.827 |
| 76.200 | 0.632 | 0.364 | 0.364 | 0.364 | 0.774 | 0.632 | 0.364 | 0.364 | 0.364 | 0.775 |
| 78.000 | 0.691 | 0.465 | 0.465 | 0.465 | 0.810 | 0.691 | 0.465 | 0.465 | 0.465 | 0.811 |
| 79.500 | 0.720 | 0.516 | 0.516 | 0.516 | 0.720 | 0.720 | 0.516 | 0.516 | 0.516 | 0.720 |
| 81.600 | 0.708 | 0.494 | 0.494 | 0.494 | 0.708 | 0.708 | 0.494 | 0.494 | 0.494 | 0.708 |
| 83.800 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 | 0.821 | 0.690 | 0.690 | 0.690 | 0.821 |
| 86.000 | 0.864 | 0.764 | 0.764 | 0.764 | 0.864 | 0.864 | 0.764 | 0.764 | 0.764 | 0.864 |
| 88.100 | 0.918 | 0.858 | 0.858 | 0.858 | 0.918 | 0.918 | 0.858 | 0.858 | 0.858 | 0.918 |
| 89.900 | 0.984 | 0.972 | 0.972 | 0.972 | 0.984 | 0.984 | 0.972 | 0.972 | 0.972 | 0.984 |
| 91.500 | 0.994 | 0.989 | 0.989 | 0.989 | 0.994 | 0.994 | 0.989 | 0.989 | 0.989 | 0.994 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table D.2 (continued)

| AXL[a] | VALUE OF I IS: 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.001 | 1.002 | 1.002 | 1.002 | 1.001 |
| 1.800 | 0.974 | 0.960 | 0.960 | 0.960 | 0.974 |
| 3.400 | 0.945 | 0.916 | 0.916 | 0.916 | 0.945 |
| 5.000 | 0.947 | 0.919 | 0.919 | 0.919 | 0.947 |
| 6.900 | 0.960 | 0.938 | 0.938 | 0.938 | 0.960 |
| 8.800 | 0.982 | 0.973 | 0.973 | 0.973 | 0.982 |
| 11.500 | 0.982 | 0.972 | 0.972 | 0.972 | 0.982 |
| 13.300 | 0.956 | 0.933 | 0.933 | 0.933 | 0.956 |
| 15.100 | 0.940 | 0.907 | 0.907 | 0.907 | 0.940 |
| 16.800 | 0.924 | 0.882 | 0.882 | 0.882 | 0.924 |
| 18.100 | 0.915 | 0.870 | 0.870 | 0.870 | 0.915 |
| 19.500 | 0.896 | 0.840 | 0.840 | 0.840 | 0.896 |
| 21.400 | 0.908 | 0.858 | 0.858 | 0.858 | 0.908 |
| 23.200 | 0.907 | 0.857 | 0.857 | 0.857 | 0.907 |
| 25.000 | 0.910 | 0.862 | 0.862 | 0.862 | 0.910 |
| 26.900 | 0.917 | 0.872 | 0.872 | 0.872 | 0.917 |
| 28.500 | 0.913 | 0.865 | 0.865 | 0.865 | 0.913 |
| 30.000 | 0.914 | 0.867 | 0.867 | 0.867 | 0.914 |
| 32.000 | 0.916 | 0.871 | 0.871 | 0.871 | 0.916 |
| 34.000 | 0.919 | 0.875 | 0.875 | 0.875 | 0.919 |
| 35.900 | 0.909 | 0.860 | 0.860 | 0.860 | 0.909 |
| 37.700 | 0.894 | 0.837 | 0.837 | 0.837 | 0.894 |
| 39.500 | 0.906 | 0.855 | 0.855 | 0.855 | 0.906 |
| 41.200 | 0.880 | 0.815 | 0.815 | 0.815 | 0.880 |
| 43.300 | 0.875 | 0.807 | 0.807 | 0.807 | 0.875 |
| 44.700 | 0.891 | 0.833 | 0.833 | 0.833 | 0.891 |
| 46.200 | 0.892 | 0.834 | 0.834 | 0.834 | 0.892 |
| 47.700 | 0.882 | 0.818 | 0.818 | 0.818 | 0.882 |
| 49.700 | 0.896 | 0.839 | 0.839 | 0.839 | 0.896 |
| 51.600 | 0.900 | 0.846 | 0.846 | 0.846 | 0.900 |
| 53.500 | 0.872 | 0.803 | 0.803 | 0.803 | 0.872 |
| 54.900 | 0.881 | 0.816 | 0.816 | 0.816 | 0.881 |
| 56.200 | 0.846 | 0.763 | 0.763 | 0.763 | 0.846 |
| 57.600 | 0.887 | 0.826 | 0.826 | 0.826 | 0.887 |
| 59.800 | 0.921 | 0.878 | 0.878 | 0.878 | 0.921 |
| 61.800 | 0.943 | 0.912 | 0.912 | 0.912 | 0.943 |
| 63.800 | 0.975 | 0.962 | 0.962 | 0.962 | 0.975 |
| 66.500 | 0.976 | 0.963 | 0.963 | 0.963 | 0.976 |
| 68.400 | 0.942 | 0.911 | 0.911 | 0.911 | 0.942 |
| 70.100 | 0.915 | 0.869 | 0.869 | 0.869 | 0.915 |
| 71.600 | 0.906 | 0.856 | 0.856 | 0.856 | 0.906 |
| 73.100 | 0.896 | 0.840 | 0.840 | 0.840 | 0.896 |
| 74.600 | 0.866 | 0.794 | 0.794 | 0.794 | 0.866 |
| 76.200 | 0.826 | 0.732 | 0.732 | 0.732 | 0.826 |
| 78.000 | 0.853 | 0.774 | 0.774 | 0.774 | 0.853 |
| 79.500 | 0.867 | 0.796 | 0.796 | 0.796 | 0.867 |
| 81.600 | 0.861 | 0.787 | 0.787 | 0.787 | 0.861 |
| 83.800 | 0.915 | 0.869 | 0.869 | 0.869 | 0.915 |
| 86.000 | 0.935 | 0.900 | 0.900 | 0.900 | 0.935 |
| 88.100 | 0.961 | 0.940 | 0.940 | 0.940 | 0.961 |
| 89.900 | 0.992 | 0.988 | 0.988 | 0.988 | 0.992 |
| 91.500 | 0.997 | 0.995 | 0.995 | 0.995 | 0.997 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table D.3. GFACT values for the B-2/shroud 1 COBRA-IV model based on the maximum restriction definition

| GAPXL[a] | VALUE OF K IS: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.002 | 1.004 | 1.002 | 1.010 | 1.002 | 1.010 | 1.002 | 1.010 | 1.004 | 1.004 |
| 1.800 | 0.958 | 0.934 | 0.958 | 0.826 | 0.958 | 0.826 | 0.958 | 0.826 | 0.934 | 0.934 |
| 3.400 | 0.913 | 0.865 | 0.913 | 0.642 | 0.913 | 0.642 | 0.913 | 0.642 | 0.865 | 0.865 |
| 5.000 | 0.916 | 0.869 | 0.916 | 0.654 | 0.916 | 0.654 | 0.916 | 0.654 | 0.869 | 0.869 |
| 6.900 | 0.935 | 0.899 | 0.935 | 0.732 | 0.935 | 0.732 | 0.935 | 0.732 | 0.899 | 0.899 |
| 8.800 | 0.971 | 0.955 | 0.971 | 0.880 | 0.971 | 0.880 | 0.971 | 0.880 | 0.955 | 0.955 |
| 11.500 | 0.970 | 0.953 | 0.970 | 0.875 | 0.970 | 0.875 | 0.970 | 0.875 | 0.953 | 0.953 |
| 13.300 | 0.929 | 0.890 | 0.929 | 0.709 | 0.929 | 0.709 | 0.929 | 0.709 | 0.890 | 0.890 |
| 15.100 | 0.904 | 0.852 | 0.904 | 0.606 | 0.904 | 0.606 | 0.904 | 0.606 | 0.852 | 0.852 |
| 16.800 | 0.880 | 0.814 | 0.880 | 0.508 | 0.880 | 0.508 | 0.880 | 0.508 | 0.814 | 0.814 |
| 18.100 | 0.868 | 0.796 | 0.868 | 0.459 | 0.868 | 0.459 | 0.868 | 0.459 | 0.796 | 0.796 |
| 19.500 | 0.840 | 0.753 | 0.840 | 0.346 | 0.840 | 0.346 | 0.840 | 0.346 | 0.753 | 0.753 |
| 21.400 | 0.857 | 0.780 | 0.857 | 0.415 | 0.857 | 0.415 | 0.857 | 0.415 | 0.780 | 0.780 |
| 23.200 | 0.857 | 0.778 | 0.857 | 0.412 | 0.857 | 0.412 | 0.857 | 0.412 | 0.778 | 0.778 |
| 25.000 | 0.861 | 0.785 | 0.861 | 0.430 | 0.861 | 0.430 | 0.861 | 0.430 | 0.785 | 0.785 |
| 26.900 | 0.870 | 0.800 | 0.870 | 0.469 | 0.870 | 0.469 | 0.870 | 0.469 | 0.800 | 0.800 |
| 28.500 | 0.864 | 0.790 | 0.864 | 0.443 | 0.864 | 0.443 | 0.864 | 0.443 | 0.790 | 0.790 |
| 30.000 | 0.866 | 0.792 | 0.866 | 0.449 | 0.866 | 0.449 | 0.866 | 0.449 | 0.792 | 0.792 |
| 32.000 | 0.869 | 0.797 | 0.869 | 0.462 | 0.869 | 0.462 | 0.869 | 0.462 | 0.797 | 0.797 |
| 34.000 | 0.873 | 0.803 | 0.873 | 0.478 | 0.873 | 0.478 | 0.873 | 0.478 | 0.803 | 0.803 |
| 35.900 | 0.859 | 0.783 | 0.859 | 0.423 | 0.859 | 0.423 | 0.859 | 0.423 | 0.783 | 0.783 |
| 37.700 | 0.838 | 0.750 | 0.838 | 0.336 | 0.838 | 0.336 | 0.838 | 0.336 | 0.750 | 0.750 |
| 39.500 | 0.854 | 0.775 | 0.854 | 0.403 | 0.854 | 0.403 | 0.854 | 0.403 | 0.775 | 0.775 |
| 41.200 | 0.818 | 0.719 | 0.818 | 0.254 | 0.818 | 0.254 | 0.818 | 0.254 | 0.719 | 0.719 |
| 43.300 | 0.811 | 0.708 | 0.811 | 0.225 | 0.811 | 0.225 | 0.811 | 0.225 | 0.708 | 0.708 |
| 44.700 | 0.834 | 0.743 | 0.834 | 0.319 | 0.834 | 0.319 | 0.834 | 0.319 | 0.743 | 0.743 |
| 46.200 | 0.835 | 0.746 | 0.835 | 0.325 | 0.835 | 0.325 | 0.835 | 0.325 | 0.746 | 0.746 |
| 47.700 | 0.821 | 0.723 | 0.821 | 0.266 | 0.821 | 0.266 | 0.821 | 0.266 | 0.723 | 0.723 |
| 49.700 | 0.840 | 0.753 | 0.840 | 0.344 | 0.840 | 0.344 | 0.840 | 0.344 | 0.753 | 0.753 |
| 51.600 | 0.846 | 0.762 | 0.846 | 0.369 | 0.846 | 0.369 | 0.846 | 0.369 | 0.762 | 0.762 |
| 53.500 | 0.808 | 0.703 | 0.808 | 0.213 | 0.808 | 0.213 | 0.808 | 0.213 | 0.703 | 0.703 |
| 54.900 | 0.819 | 0.720 | 0.819 | 0.258 | 0.819 | 0.258 | 0.819 | 0.258 | 0.720 | 0.720 |
| 56.200 | 0.773 | 0.649 | 0.773 | 0.069 | 0.773 | 0.069 | 0.773 | 0.069 | 0.649 | 0.649 |
| 57.600 | 0.828 | 0.734 | 0.828 | 0.296 | 0.828 | 0.296 | 0.828 | 0.296 | 0.734 | 0.734 |
| 59.800 | 0.876 | 0.808 | 0.876 | 0.491 | 0.876 | 0.491 | 0.876 | 0.491 | 0.808 | 0.808 |
| 61.800 | 0.909 | 0.859 | 0.909 | 0.625 | 0.909 | 0.625 | 0.909 | 0.625 | 0.859 | 0.859 |
| 63.800 | 0.959 | 0.936 | 0.959 | 0.831 | 0.959 | 0.831 | 0.959 | 0.831 | 0.936 | 0.936 |
| 66.500 | 0.961 | 0.939 | 0.961 | 0.839 | 0.961 | 0.839 | 0.961 | 0.839 | 0.939 | 0.939 |
| 68.400 | 0.907 | 0.857 | 0.907 | 0.620 | 0.907 | 0.620 | 0.907 | 0.620 | 0.857 | 0.857 |
| 70.100 | 0.868 | 0.795 | 0.868 | 0.457 | 0.868 | 0.457 | 0.868 | 0.457 | 0.795 | 0.795 |
| 71.600 | 0.855 | 0.776 | 0.855 | 0.406 | 0.855 | 0.406 | 0.855 | 0.406 | 0.776 | 0.776 |
| 73.100 | 0.840 | 0.753 | 0.840 | 0.346 | 0.840 | 0.346 | 0.840 | 0.346 | 0.753 | 0.753 |
| 74.600 | 0.800 | 0.690 | 0.800 | 0.178 | 0.800 | 0.178 | 0.800 | 0.178 | 0.690 | 0.690 |
| 76.200 | 0.747 | 0.609 | 0.747 | 0.0 | 0.747 | 0.0 | 0.747 | 0.0 | 0.609 | 0.609 |
| 78.000 | 0.783 | 0.664 | 0.783 | 0.109 | 0.783 | 0.109 | 0.783 | 0.109 | 0.664 | 0.664 |
| 79.500 | 0.801 | 0.693 | 0.801 | 0.185 | 0.801 | 0.185 | 0.801 | 0.185 | 0.693 | 0.693 |
| 81.600 | 0.793 | 0.680 | 0.793 | 0.152 | 0.793 | 0.152 | 0.793 | 0.152 | 0.680 | 0.680 |
| 83.800 | 0.868 | 0.795 | 0.868 | 0.457 | 0.868 | 0.457 | 0.868 | 0.457 | 0.795 | 0.795 |
| 86.000 | 0.897 | 0.841 | 0.897 | 0.579 | 0.897 | 0.579 | 0.897 | 0.579 | 0.841 | 0.841 |
| 88.100 | 0.937 | 0.902 | 0.937 | 0.741 | 0.937 | 0.741 | 0.937 | 0.741 | 0.902 | 0.902 |
| 89.900 | 0.987 | 0.980 | 0.987 | 0.947 | 0.987 | 0.947 | 0.987 | 0.947 | 0.980 | 0.980 |
| 91.500 | 0.995 | 0.992 | 0.995 | 0.979 | 0.995 | 0.979 | 0.995 | 0.979 | 0.992 | 0.992 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table D.3 (continued)

| GAPXL[a] | VALUE OF K IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.004 | 1.004 | 1.010 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.934 | 0.826 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.865 | 0.865 | 0.642 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.869 | 0.869 | 0.654 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.899 | 0.899 | 0.732 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.955 | 0.955 | 0.880 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.953 | 0.953 | 0.875 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.890 | 0.890 | 0.709 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.852 | 0.852 | 0.606 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.814 | 0.814 | 0.508 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.796 | 0.796 | 0.459 |
| 19.500 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.753 | 0.346 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.780 | 0.780 | 0.415 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.778 | 0.778 | 0.412 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.785 | 0.785 | 0.430 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.800 | 0.800 | 0.469 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.790 | 0.790 | 0.443 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.792 | 0.792 | 0.449 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.797 | 0.797 | 0.462 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.803 | 0.803 | 0.478 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.783 | 0.783 | 0.423 |
| 37.700 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.750 | 0.750 | 0.336 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.775 | 0.403 |
| 41.200 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.719 | 0.719 | 0.254 |
| 43.300 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.708 | 0.708 | 0.225 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.743 | 0.743 | 0.319 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.746 | 0.746 | 0.325 |
| 47.700 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.723 | 0.723 | 0.266 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.753 | 0.753 | 0.344 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.762 | 0.369 |
| 53.500 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.703 | 0.703 | 0.213 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.720 | 0.720 | 0.258 |
| 56.200 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.649 | 0.649 | 0.069 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.734 | 0.296 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.808 | 0.808 | 0.491 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.859 | 0.859 | 0.625 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.936 | 0.936 | 0.831 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.939 | 0.939 | 0.839 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.857 | 0.857 | 0.620 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.795 | 0.457 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.776 | 0.776 | 0.406 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.753 | 0.346 |
| 74.600 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.690 | 0.690 | 0.178 |
| 76.200 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.609 | 0.609 | 0.0 |
| 78.000 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.664 | 0.664 | 0.109 |
| 79.500 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.693 | 0.693 | 0.185 |
| 81.600 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.680 | 0.680 | 0.152 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.795 | 0.457 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.841 | 0.841 | 0.579 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.902 | 0.902 | 0.741 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.980 | 0.980 | 0.947 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.992 | 0.992 | 0.979 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table D.3 (continued)

| GAPXL[a] | VALUE OF K IS: 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.004 | 1.004 | 1.010 | 1.010 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.934 | 0.826 | 0.826 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.865 | 0.865 | 0.642 | 0.642 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.869 | 0.869 | 0.654 | 0.654 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.899 | 0.899 | 0.732 | 0.732 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.955 | 0.955 | 0.880 | 0.880 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.953 | 0.953 | 0.875 | 0.875 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.890 | 0.890 | 0.709 | 0.709 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.852 | 0.852 | 0.606 | 0.606 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.814 | 0.814 | 0.508 | 0.508 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.796 | 0.796 | 0.459 | 0.459 |
| 19.500 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.753 | 0.346 | 0.346 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.780 | 0.780 | 0.415 | 0.415 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.778 | 0.778 | 0.412 | 0.412 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.785 | 0.785 | 0.430 | 0.430 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.800 | 0.800 | 0.469 | 0.469 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.790 | 0.790 | 0.443 | 0.443 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.792 | 0.792 | 0.449 | 0.449 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.797 | 0.797 | 0.462 | 0.462 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.803 | 0.803 | 0.478 | 0.478 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.783 | 0.783 | 0.423 | 0.423 |
| 37.700 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.750 | 0.750 | 0.336 | 0.336 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.775 | 0.403 | 0.403 |
| 41.200 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.719 | 0.719 | 0.254 | 0.254 |
| 43.300 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.708 | 0.708 | 0.225 | 0.225 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.743 | 0.743 | 0.319 | 0.319 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.746 | 0.746 | 0.325 | 0.325 |
| 47.700 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.723 | 0.723 | 0.266 | 0.266 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.753 | 0.753 | 0.344 | 0.344 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.762 | 0.369 | 0.369 |
| 53.500 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.703 | 0.703 | 0.213 | 0.213 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.720 | 0.720 | 0.258 | 0.258 |
| 56.200 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.649 | 0.649 | 0.069 | 0.069 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.734 | 0.296 | 0.296 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.808 | 0.808 | 0.491 | 0.491 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.859 | 0.859 | 0.625 | 0.625 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.936 | 0.936 | 0.831 | 0.831 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.939 | 0.939 | 0.839 | 0.839 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.857 | 0.857 | 0.620 | 0.620 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.795 | 0.457 | 0.457 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.776 | 0.776 | 0.406 | 0.406 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.753 | 0.346 | 0.346 |
| 74.600 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.690 | 0.690 | 0.178 | 0.178 |
| 76.200 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.609 | 0.609 | 0.0 | 0.0 |
| 78.000 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.664 | 0.664 | 0.109 | 0.109 |
| 79.500 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.693 | 0.693 | 0.185 | 0.185 |
| 81.600 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.680 | 0.680 | 0.152 | 0.152 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.795 | 0.457 | 0.457 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.841 | 0.841 | 0.579 | 0.579 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.902 | 0.902 | 0.741 | 0.741 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.980 | 0.980 | 0.947 | 0.947 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.992 | 0.992 | 0.979 | 0.979 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table D.3 (continued)

| GAPXL[a] | VALUE OF K IS: 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.004 | 1.002 | 1.002 | 1.002 | 1.002 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.934 | 0.958 | 0.958 | 0.958 | 0.958 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.865 | 0.913 | 0.913 | 0.913 | 0.913 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.869 | 0.916 | 0.916 | 0.916 | 0.916 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.899 | 0.935 | 0.935 | 0.935 | 0.935 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.955 | 0.971 | 0.971 | 0.971 | 0.971 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.953 | 0.970 | 0.970 | 0.970 | 0.970 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.890 | 0.929 | 0.929 | 0.929 | 0.929 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.852 | 0.904 | 0.904 | 0.904 | 0.904 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.814 | 0.880 | 0.880 | 0.880 | 0.880 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.796 | 0.868 | 0.868 | 0.868 | 0.868 |
| 19.500 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.840 | 0.840 | 0.840 | 0.840 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.780 | 0.857 | 0.857 | 0.857 | 0.857 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.778 | 0.857 | 0.857 | 0.857 | 0.857 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.785 | 0.861 | 0.861 | 0.861 | 0.861 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.800 | 0.870 | 0.870 | 0.870 | 0.870 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.790 | 0.864 | 0.864 | 0.864 | 0.864 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.792 | 0.866 | 0.866 | 0.866 | 0.866 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.797 | 0.869 | 0.869 | 0.869 | 0.869 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.803 | 0.873 | 0.873 | 0.873 | 0.873 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.783 | 0.859 | 0.859 | 0.859 | 0.859 |
| 37.700 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.750 | 0.838 | 0.838 | 0.838 | 0.838 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.775 | 0.854 | 0.854 | 0.854 | 0.854 |
| 41.200 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.719 | 0.818 | 0.818 | 0.818 | 0.818 |
| 43.300 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.708 | 0.811 | 0.811 | 0.811 | 0.811 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.743 | 0.834 | 0.834 | 0.834 | 0.834 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.746 | 0.835 | 0.835 | 0.835 | 0.835 |
| 47.700 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.723 | 0.821 | 0.821 | 0.821 | 0.821 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.753 | 0.840 | 0.840 | 0.840 | 0.840 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.762 | 0.846 | 0.846 | 0.846 | 0.846 |
| 53.500 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.703 | 0.808 | 0.808 | 0.808 | 0.808 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.720 | 0.819 | 0.819 | 0.819 | 0.819 |
| 56.200 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.649 | 0.773 | 0.773 | 0.773 | 0.773 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.734 | 0.828 | 0.828 | 0.828 | 0.828 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.808 | 0.876 | 0.876 | 0.876 | 0.876 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.859 | 0.909 | 0.909 | 0.909 | 0.909 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.936 | 0.959 | 0.959 | 0.959 | 0.959 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.939 | 0.961 | 0.961 | 0.961 | 0.961 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.857 | 0.907 | 0.907 | 0.907 | 0.907 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.868 | 0.868 | 0.868 | 0.868 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.776 | 0.855 | 0.855 | 0.855 | 0.855 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.753 | 0.840 | 0.840 | 0.840 | 0.840 |
| 74.600 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.690 | 0.800 | 0.800 | 0.800 | 0.800 |
| 76.200 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.609 | 0.747 | 0.747 | 0.747 | 0.747 |
| 78.000 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.664 | 0.783 | 0.783 | 0.783 | 0.783 |
| 79.500 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.693 | 0.801 | 0.801 | 0.801 | 0.801 |
| 81.600 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.680 | 0.793 | 0.793 | 0.793 | 0.793 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.795 | 0.868 | 0.868 | 0.868 | 0.868 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.841 | 0.897 | 0.897 | 0.897 | 0.897 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.902 | 0.937 | 0.937 | 0.937 | 0.937 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.980 | 0.987 | 0.987 | 0.987 | 0.987 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.992 | 0.995 | 0.995 | 0.995 | 0.995 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]GAPXL values are the centimeters from the bottom of the heated zone.

# Appendix E

## B-2/SHROUD 2 BUNDLE-AVERAGED GEOMETRY DATA, MINIMUM RESTRICTION DEFINITION

The data in Appendix E represent the input from card groups 5 and 6 as required by ref. 2 for the B-2/shroud 2 COBRA-IV model based on the minimum restriction definition.

Table E.1. Shroud flow area reductions for the B-2/shroud 2 COBRA-IV model based on the minimum restriction definition

| AXL[a] | FRACTIONAL SHROUD FLOW AREA |
|---|---|
| -47.676 | 1.000 |
| 0.000 | 1.003 |
| 1.800 | 0.950 |
| 3.400 | 0.894 |
| 5.000 | 0.898 |
| 6.900 | 0.922 |
| 8.800 | 0.966 |
| 11.500 | 0.964 |
| 13.300 | 0.915 |
| 15.100 | 0.883 |
| 16.900 | 0.851 |
| 18.100 | 0.835 |
| 19.500 | 0.810 |
| 21.400 | 0.821 |
| 23.200 | 0.820 |
| 25.000 | 0.826 |
| 26.900 | 0.838 |
| 28.500 | 0.830 |
| 30.000 | 0.832 |
| 32.000 | 0.836 |
| 34.000 | 0.842 |
| 35.900 | 0.823 |
| 37.700 | 0.799 |
| 39.500 | 0.817 |
| 41.200 | 0.785 |
| 43.300 | 0.780 |
| 44.700 | 0.788 |
| 46.200 | 0.790 |
| 47.700 | 0.780 |
| 49.700 | 0.797 |
| 51.600 | 0.805 |
| 53.500 | 0.778 |
| 54.900 | 0.767 |
| 56.200 | 0.744 |
| 57.600 | 0.780 |
| 59.800 | 0.846 |
| 61.800 | 0.889 |
| 63.800 | 0.951 |
| 66.500 | 0.954 |
| 68.400 | 0.887 |
| 70.100 | 0.835 |
| 71.600 | 0.818 |
| 73.100 | 0.797 |
| 74.600 | 0.747 |
| 76.200 | 0.720 |
| 78.000 | 0.728 |
| 79.500 | 0.747 |
| 81.600 | 0.763 |
| 83.800 | 0.835 |
| 86.000 | 0.874 |
| 88.100 | 0.924 |
| 89.900 | 0.985 |
| 91.500 | 0.994 |
| 95.987 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table E.2. AFACT values for the B-2/shroud 2 COBRA-IV model based on the minimum restriction definition

| AXL[a] | VALUE OF I IS: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.001 | 1.002 | 1.002 | 1.002 | 1.001 | 1.002 | 1.005 | 1.005 | 1.005 | 1.002 |
| 1.800 | 0.983 | 0.964 | 0.964 | 0.964 | 0.983 | 0.963 | 0.906 | 0.906 | 0.906 | 0.963 |
| 3.400 | 0.964 | 0.924 | 0.924 | 0.924 | 0.964 | 0.921 | 0.801 | 0.801 | 0.801 | 0.921 |
| 5.000 | 0.965 | 0.927 | 0.927 | 0.927 | 0.965 | 0.924 | 0.808 | 0.808 | 0.908 | 0.924 |
| 6.900 | 0.973 | 0.944 | 0.944 | 0.944 | 0.973 | 0.942 | 0.853 | 0.853 | 0.853 | 0.942 |
| 8.800 | 0.988 | 0.976 | 0.976 | 0.976 | 0.988 | 0.975 | 0.936 | 0.936 | 0.936 | 0.975 |
| 11.500 | 0.988 | 0.974 | 0.974 | 0.974 | 0.988 | 0.974 | 0.933 | 0.933 | 0.933 | 0.974 |
| 13.300 | 0.971 | 0.939 | 0.939 | 0.939 | 0.971 | 0.937 | 0.840 | 0.840 | 0.840 | 0.937 |
| 15.100 | 0.960 | 0.916 | 0.916 | 0.916 | 0.960 | 0.913 | 0.780 | 0.780 | 0.780 | 0.913 |
| 16.800 | 0.950 | 0.894 | 0.894 | 0.894 | 0.950 | 0.890 | 0.721 | 0.721 | 0.721 | 0.890 |
| 18.100 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 | 0.878 | 0.691 | 0.691 | 0.691 | 0.878 |
| 19.500 | 0.936 | 0.864 | 0.864 | 0.864 | 0.936 | 0.859 | 0.644 | 0.644 | 0.644 | 0.859 |
| 21.400 | 0.939 | 0.872 | 0.872 | 0.872 | 0.939 | 0.867 | 0.664 | 0.664 | 0.664 | 0.867 |
| 23.200 | 0.939 | 0.871 | 0.871 | 0.871 | 0.939 | 0.866 | 0.662 | 0.662 | 0.662 | 0.866 |
| 25.000 | 0.941 | 0.876 | 0.876 | 0.876 | 0.941 | 0.871 | 0.673 | 0.673 | 0.673 | 0.871 |
| 26.900 | 0.945 | 0.885 | 0.885 | 0.885 | 0.945 | 0.880 | 0.697 | 0.697 | 0.697 | 0.880 |
| 28.500 | 0.942 | 0.879 | 0.879 | 0.879 | 0.942 | 0.874 | 0.681 | 0.681 | 0.681 | 0.874 |
| 30.000 | 0.943 | 0.880 | 0.880 | 0.880 | 0.943 | 0.876 | 0.685 | 0.685 | 0.685 | 0.876 |
| 32.000 | 0.944 | 0.883 | 0.883 | 0.883 | 0.944 | 0.879 | 0.693 | 0.693 | 0.693 | 0.879 |
| 34.000 | 0.946 | 0.887 | 0.887 | 0.887 | 0.946 | 0.883 | 0.703 | 0.703 | 0.703 | 0.883 |
| 35.900 | 0.940 | 0.874 | 0.874 | 0.874 | 0.940 | 0.869 | 0.669 | 0.669 | 0.669 | 0.869 |
| 37.700 | 0.932 | 0.856 | 0.856 | 0.856 | 0.932 | 0.851 | 0.623 | 0.623 | 0.623 | 0.851 |
| 39.500 | 0.938 | 0.869 | 0.869 | 0.869 | 0.938 | 0.864 | 0.656 | 0.656 | 0.656 | 0.864 |
| 41.200 | 0.927 | 0.847 | 0.847 | 0.847 | 0.927 | 0.841 | 0.597 | 0.597 | 0.597 | 0.841 |
| 43.300 | 0.925 | 0.843 | 0.843 | 0.843 | 0.925 | 0.837 | 0.587 | 0.587 | 0.587 | 0.837 |
| 44.700 | 0.928 | 0.849 | 0.849 | 0.849 | 0.928 | 0.843 | 0.603 | 0.603 | 0.603 | 0.843 |
| 46.200 | 0.929 | 0.850 | 0.850 | 0.850 | 0.929 | 0.845 | 0.607 | 0.607 | 0.607 | 0.845 |
| 47.700 | 0.925 | 0.843 | 0.843 | 0.843 | 0.925 | 0.837 | 0.588 | 0.588 | 0.588 | 0.837 |
| 49.700 | 0.931 | 0.855 | 0.855 | 0.855 | 0.931 | 0.849 | 0.619 | 0.619 | 0.619 | 0.849 |
| 51.600 | 0.934 | 0.861 | 0.861 | 0.861 | 0.934 | 0.856 | 0.635 | 0.635 | 0.635 | 0.856 |
| 53.500 | 0.925 | 0.841 | 0.841 | 0.841 | 0.925 | 0.835 | 0.583 | 0.583 | 0.583 | 0.835 |
| 54.900 | 0.921 | 0.834 | 0.834 | 0.834 | 0.921 | 0.828 | 0.564 | 0.564 | 0.564 | 0.828 |
| 56.200 | 0.913 | 0.817 | 0.817 | 0.817 | 0.913 | 0.810 | 0.520 | 0.520 | 0.520 | 0.810 |
| 57.600 | 0.925 | 0.843 | 0.843 | 0.843 | 0.925 | 0.837 | 0.588 | 0.588 | 0.588 | 0.837 |
| 59.800 | 0.948 | 0.890 | 0.890 | 0.890 | 0.948 | 0.886 | 0.711 | 0.711 | 0.711 | 0.886 |
| 61.800 | 0.962 | 0.920 | 0.920 | 0.920 | 0.962 | 0.917 | 0.791 | 0.791 | 0.791 | 0.917 |
| 63.800 | 0.984 | 0.965 | 0.965 | 0.965 | 0.984 | 0.964 | 0.909 | 0.909 | 0.909 | 0.964 |
| 66.500 | 0.984 | 0.967 | 0.967 | 0.967 | 0.984 | 0.966 | 0.913 | 0.913 | 0.913 | 0.966 |
| 68.400 | 0.962 | 0.919 | 0.919 | 0.919 | 0.962 | 0.916 | 0.788 | 0.788 | 0.788 | 0.916 |
| 70.100 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 |
| 71.600 | 0.938 | 0.870 | 0.870 | 0.870 | 0.938 | 0.865 | 0.658 | 0.658 | 0.658 | 0.865 |
| 73.100 | 0.931 | 0.855 | 0.855 | 0.855 | 0.931 | 0.850 | 0.620 | 0.620 | 0.620 | 0.850 |
| 74.600 | 0.914 | 0.820 | 0.820 | 0.920 | 0.914 | 0.813 | 0.526 | 0.526 | 0.526 | 0.813 |
| 76.200 | 0.905 | 0.800 | 0.800 | 0.800 | 0.905 | 0.793 | 0.475 | 0.475 | 0.475 | 0.793 |
| 78.000 | 0.908 | 0.806 | 0.806 | 0.806 | 0.908 | 0.798 | 0.490 | 0.490 | 0.490 | 0.798 |
| 79.500 | 0.914 | 0.820 | 0.820 | 0.820 | 0.914 | 0.813 | 0.526 | 0.526 | 0.526 | 0.813 |
| 81.600 | 0.920 | 0.831 | 0.831 | 0.831 | 0.920 | 0.825 | 0.556 | 0.556 | 0.556 | 0.825 |
| 83.800 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 |
| 86.000 | 0.957 | 0.910 | 0.910 | 0.910 | 0.957 | 0.907 | 0.764 | 0.764 | 0.764 | 0.907 |
| 88.100 | 0.974 | 0.946 | 0.946 | 0.946 | 0.974 | 0.944 | 0.858 | 0.858 | 0.858 | 0.944 |
| 89.900 | 0.995 | 0.989 | 0.989 | 0.989 | 0.995 | 0.989 | 0.972 | 0.972 | 0.972 | 0.989 |
| 91.500 | 0.998 | 0.996 | 0.996 | 0.996 | 0.998 | 0.996 | 0.989 | 0.989 | 0.989 | 0.996 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table E.2 (continued)

| AXL[a] | VALUE OF I IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.002 | 1.005 | 1.005 | 1.005 | 1.002 | 1.002 | 1.005 | 1.005 | 1.005 | 1.002 |
| 1.800 | 0.963 | 0.906 | 0.906 | 0.906 | 0.963 | 0.963 | 0.906 | 0.906 | 0.906 | 0.963 |
| 3.400 | 0.921 | 0.801 | 0.801 | 0.801 | 0.921 | 0.921 | 0.801 | 0.801 | 0.801 | 0.921 |
| 5.000 | 0.924 | 0.808 | 0.808 | 0.808 | 0.924 | 0.924 | 0.808 | 0.808 | 0.808 | 0.924 |
| 6.900 | 0.942 | 0.853 | 0.853 | 0.853 | 0.942 | 0.942 | 0.853 | 0.853 | 0.853 | 0.942 |
| 8.800 | 0.975 | 0.936 | 0.936 | 0.936 | 0.975 | 0.975 | 0.936 | 0.936 | 0.936 | 0.975 |
| 11.500 | 0.974 | 0.933 | 0.933 | 0.933 | 0.974 | 0.974 | 0.933 | 0.933 | 0.933 | 0.974 |
| 13.300 | 0.937 | 0.840 | 0.840 | 0.840 | 0.937 | 0.937 | 0.840 | 0.840 | 0.840 | 0.937 |
| 15.100 | 0.913 | 0.780 | 0.780 | 0.780 | 0.913 | 0.913 | 0.780 | 0.780 | 0.780 | 0.913 |
| 16.800 | 0.890 | 0.721 | 0.721 | 0.721 | 0.890 | 0.890 | 0.721 | 0.721 | 0.721 | 0.890 |
| 18.100 | 0.878 | 0.691 | 0.691 | 0.691 | 0.878 | 0.878 | 0.691 | 0.691 | 0.691 | 0.878 |
| 19.500 | 0.859 | 0.644 | 0.644 | 0.644 | 0.859 | 0.859 | 0.644 | 0.644 | 0.644 | 0.859 |
| 21.400 | 0.867 | 0.664 | 0.664 | 0.664 | 0.867 | 0.867 | 0.664 | 0.664 | 0.664 | 0.867 |
| 23.200 | 0.866 | 0.662 | 0.662 | 0.662 | 0.866 | 0.866 | 0.662 | 0.662 | 0.662 | 0.866 |
| 25.000 | 0.871 | 0.673 | 0.673 | 0.673 | 0.871 | 0.871 | 0.673 | 0.673 | 0.673 | 0.871 |
| 26.900 | 0.880 | 0.697 | 0.697 | 0.697 | 0.880 | 0.880 | 0.697 | 0.697 | 0.697 | 0.880 |
| 28.500 | 0.874 | 0.681 | 0.681 | 0.681 | 0.874 | 0.874 | 0.681 | 0.681 | 0.681 | 0.874 |
| 30.000 | 0.876 | 0.685 | 0.685 | 0.685 | 0.876 | 0.876 | 0.685 | 0.685 | 0.685 | 0.876 |
| 32.000 | 0.879 | 0.693 | 0.693 | 0.693 | 0.879 | 0.879 | 0.693 | 0.693 | 0.693 | 0.879 |
| 34.000 | 0.883 | 0.703 | 0.703 | 0.703 | 0.883 | 0.883 | 0.703 | 0.703 | 0.703 | 0.883 |
| 35.900 | 0.869 | 0.669 | 0.669 | 0.669 | 0.869 | 0.869 | 0.669 | 0.669 | 0.669 | 0.869 |
| 37.700 | 0.851 | 0.623 | 0.623 | 0.623 | 0.851 | 0.851 | 0.623 | 0.623 | 0.623 | 0.851 |
| 39.500 | 0.864 | 0.656 | 0.656 | 0.656 | 0.864 | 0.864 | 0.656 | 0.656 | 0.656 | 0.864 |
| 41.200 | 0.841 | 0.597 | 0.597 | 0.597 | 0.841 | 0.841 | 0.597 | 0.597 | 0.597 | 0.841 |
| 43.300 | 0.837 | 0.587 | 0.587 | 0.587 | 0.837 | 0.837 | 0.587 | 0.587 | 0.587 | 0.837 |
| 44.700 | 0.843 | 0.603 | 0.603 | 0.603 | 0.843 | 0.843 | 0.603 | 0.603 | 0.603 | 0.843 |
| 46.200 | 0.845 | 0.607 | 0.607 | 0.607 | 0.845 | 0.845 | 0.607 | 0.607 | 0.607 | 0.845 |
| 47.700 | 0.837 | 0.588 | 0.588 | 0.588 | 0.837 | 0.837 | 0.588 | 0.588 | 0.588 | 0.837 |
| 49.700 | 0.849 | 0.619 | 0.619 | 0.619 | 0.849 | 0.849 | 0.619 | 0.619 | 0.619 | 0.849 |
| 51.600 | 0.856 | 0.635 | 0.635 | 0.635 | 0.856 | 0.856 | 0.635 | 0.635 | 0.635 | 0.856 |
| 53.500 | 0.835 | 0.583 | 0.583 | 0.583 | 0.835 | 0.835 | 0.583 | 0.583 | 0.583 | 0.835 |
| 54.900 | 0.828 | 0.564 | 0.564 | 0.564 | 0.828 | 0.828 | 0.564 | 0.564 | 0.564 | 0.828 |
| 56.200 | 0.810 | 0.520 | 0.520 | 0.520 | 0.810 | 0.810 | 0.520 | 0.520 | 0.520 | 0.810 |
| 57.600 | 0.837 | 0.588 | 0.588 | 0.588 | 0.837 | 0.837 | 0.588 | 0.588 | 0.588 | 0.837 |
| 59.800 | 0.886 | 0.711 | 0.711 | 0.711 | 0.886 | 0.886 | 0.711 | 0.711 | 0.711 | 0.886 |
| 61.800 | 0.917 | 0.791 | 0.791 | 0.791 | 0.917 | 0.917 | 0.791 | 0.791 | 0.791 | 0.917 |
| 63.800 | 0.964 | 0.909 | 0.909 | 0.909 | 0.964 | 0.964 | 0.909 | 0.909 | 0.909 | 0.964 |
| 66.500 | 0.966 | 0.913 | 0.913 | 0.913 | 0.966 | 0.966 | 0.913 | 0.913 | 0.913 | 0.966 |
| 68.400 | 0.916 | 0.788 | 0.788 | 0.788 | 0.916 | 0.916 | 0.788 | 0.788 | 0.788 | 0.916 |
| 70.100 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 |
| 71.600 | 0.865 | 0.658 | 0.658 | 0.658 | 0.865 | 0.865 | 0.658 | 0.658 | 0.658 | 0.865 |
| 73.100 | 0.850 | 0.620 | 0.620 | 0.620 | 0.850 | 0.850 | 0.620 | 0.620 | 0.620 | 0.850 |
| 74.600 | 0.813 | 0.526 | 0.526 | 0.526 | 0.813 | 0.813 | 0.526 | 0.526 | 0.526 | 0.813 |
| 76.200 | 0.793 | 0.475 | 0.475 | 0.475 | 0.793 | 0.793 | 0.475 | 0.475 | 0.475 | 0.793 |
| 78.000 | 0.798 | 0.490 | 0.490 | 0.490 | 0.798 | 0.798 | 0.490 | 0.490 | 0.490 | 0.798 |
| 79.500 | 0.813 | 0.526 | 0.526 | 0.526 | 0.813 | 0.813 | 0.526 | 0.526 | 0.526 | 0.813 |
| 81.600 | 0.825 | 0.556 | 0.556 | 0.556 | 0.825 | 0.825 | 0.556 | 0.556 | 0.556 | 0.825 |
| 83.800 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 |
| 86.000 | 0.907 | 0.764 | 0.764 | 0.764 | 0.907 | 0.907 | 0.764 | 0.764 | 0.764 | 0.907 |
| 88.100 | 0.944 | 0.858 | 0.858 | 0.858 | 0.944 | 0.944 | 0.858 | 0.858 | 0.858 | 0.944 |
| 89.900 | 0.989 | 0.972 | 0.972 | 0.972 | 0.989 | 0.989 | 0.972 | 0.972 | 0.972 | 0.989 |
| 91.500 | 0.996 | 0.989 | 0.989 | 0.989 | 0.996 | 0.996 | 0.989 | 0.989 | 0.989 | 0.996 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table E.2 (continued)

| AXL[a] | VALUE OF I IS: 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.001 | 1.002 | 1.002 | 1.002 | 1.001 |
| 1.800 | 0.983 | 0.964 | 0.964 | 0.964 | 0.983 |
| 3.400 | 0.964 | 0.924 | 0.924 | 0.924 | 0.964 |
| 5.000 | 0.965 | 0.927 | 0.927 | 0.927 | 0.965 |
| 6.900 | 0.973 | 0.944 | 0.944 | 0.944 | 0.973 |
| 8.800 | 0.988 | 0.976 | 0.976 | 0.976 | 0.988 |
| 11.500 | 0.988 | 0.974 | 0.974 | 0.974 | 0.988 |
| 13.300 | 0.971 | 0.939 | 0.939 | 0.939 | 0.971 |
| 15.100 | 0.960 | 0.916 | 0.916 | 0.916 | 0.960 |
| 16.800 | 0.950 | 0.894 | 0.894 | 0.894 | 0.950 |
| 18.100 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 |
| 19.500 | 0.936 | 0.864 | 0.864 | 0.864 | 0.936 |
| 21.400 | 0.939 | 0.872 | 0.872 | 0.872 | 0.939 |
| 23.200 | 0.939 | 0.871 | 0.871 | 0.871 | 0.939 |
| 25.000 | 0.941 | 0.876 | 0.876 | 0.876 | 0.941 |
| 26.900 | 0.945 | 0.885 | 0.885 | 0.885 | 0.945 |
| 28.500 | 0.942 | 0.879 | 0.879 | 0.879 | 0.942 |
| 30.000 | 0.943 | 0.880 | 0.880 | 0.880 | 0.943 |
| 32.000 | 0.944 | 0.883 | 0.883 | 0.883 | 0.944 |
| 34.000 | 0.946 | 0.887 | 0.887 | 0.887 | 0.946 |
| 35.900 | 0.940 | 0.874 | 0.874 | 0.874 | 0.940 |
| 37.700 | 0.932 | 0.856 | 0.856 | 0.856 | 0.932 |
| 39.500 | 0.938 | 0.869 | 0.869 | 0.869 | 0.938 |
| 41.200 | 0.927 | 0.847 | 0.847 | 0.847 | 0.927 |
| 43.300 | 0.925 | 0.843 | 0.843 | 0.843 | 0.925 |
| 44.700 | 0.928 | 0.849 | 0.849 | 0.849 | 0.928 |
| 46.200 | 0.929 | 0.850 | 0.850 | 0.850 | 0.929 |
| 47.700 | 0.925 | 0.843 | 0.843 | 0.843 | 0.925 |
| 49.700 | 0.931 | 0.855 | 0.855 | 0.855 | 0.931 |
| 51.600 | 0.934 | 0.861 | 0.861 | 0.861 | 0.934 |
| 53.500 | 0.925 | 0.841 | 0.841 | 0.841 | 0.925 |
| 54.900 | 0.921 | 0.834 | 0.834 | 0.834 | 0.921 |
| 56.200 | 0.913 | 0.817 | 0.817 | 0.817 | 0.913 |
| 57.600 | 0.925 | 0.843 | 0.843 | 0.843 | 0.925 |
| 59.800 | 0.948 | 0.890 | 0.890 | 0.890 | 0.948 |
| 61.800 | 0.962 | 0.920 | 0.920 | 0.920 | 0.962 |
| 63.800 | 0.984 | 0.965 | 0.965 | 0.965 | 0.984 |
| 66.500 | 0.984 | 0.967 | 0.967 | 0.967 | 0.984 |
| 68.400 | 0.962 | 0.919 | 0.919 | 0.919 | 0.962 |
| 70.100 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 |
| 71.600 | 0.938 | 0.870 | 0.870 | 0.870 | 0.938 |
| 73.100 | 0.931 | 0.855 | 0.855 | 0.855 | 0.931 |
| 74.600 | 0.914 | 0.820 | 0.820 | 0.820 | 0.914 |
| 76.200 | 0.905 | 0.800 | 0.800 | 0.800 | 0.905 |
| 78.000 | 0.908 | 0.806 | 0.806 | 0.806 | 0.908 |
| 79.500 | 0.914 | 0.820 | 0.820 | 0.820 | 0.914 |
| 81.600 | 0.920 | 0.831 | 0.831 | 0.831 | 0.920 |
| 83.800 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 |
| 86.000 | 0.957 | 0.910 | 0.910 | 0.910 | 0.957 |
| 88.100 | 0.974 | 0.946 | 0.946 | 0.946 | 0.974 |
| 89.900 | 0.995 | 0.989 | 0.989 | 0.989 | 0.995 |
| 91.500 | 0.998 | 0.996 | 0.996 | 0.996 | 0.998 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table E.3. GFACT values for the B-2/shroud 2 COBRA-IV model based on the minimum restriction definition

| GAPXL[a] | VALUE OF K IS: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.002 | 1.002 | 1.002 | 1.010 | 1.002 | 1.010 | 1.002 | 1.010 | 1.002 | 1.002 |
| 1.800 | 0.963 | 0.961 | 0.963 | 0.826 | 0.963 | 0.826 | 0.963 | 0.826 | 0.961 | 0.961 |
| 3.400 | 0.923 | 0.920 | 0.923 | 0.642 | 0.923 | 0.642 | 0.923 | 0.642 | 0.920 | 0.920 |
| 5.000 | 0.926 | 0.922 | 0.926 | 0.654 | 0.926 | 0.654 | 0.926 | 0.654 | 0.922 | 0.922 |
| 6.900 | 0.943 | 0.940 | 0.943 | 0.732 | 0.943 | 0.732 | 0.943 | 0.732 | 0.940 | 0.940 |
| 8.800 | 0.974 | 0.973 | 0.974 | 0.880 | 0.974 | 0.880 | 0.974 | 0.880 | 0.973 | 0.973 |
| 11.500 | 0.973 | 0.972 | 0.973 | 0.875 | 0.973 | 0.875 | 0.973 | 0.875 | 0.972 | 0.972 |
| 13.300 | 0.938 | 0.935 | 0.938 | 0.709 | 0.938 | 0.709 | 0.938 | 0.709 | 0.935 | 0.935 |
| 15.100 | 0.916 | 0.912 | 0.916 | 0.606 | 0.916 | 0.606 | 0.916 | 0.606 | 0.912 | 0.912 |
| 16.800 | 0.895 | 0.890 | 0.895 | 0.508 | 0.895 | 0.508 | 0.895 | 0.508 | 0.890 | 0.890 |
| 18.100 | 0.884 | 0.879 | 0.884 | 0.459 | 0.884 | 0.459 | 0.884 | 0.459 | 0.879 | 0.879 |
| 19.500 | 0.868 | 0.862 | 0.868 | 0.383 | 0.868 | 0.383 | 0.868 | 0.383 | 0.862 | 0.862 |
| 21.400 | 0.875 | 0.869 | 0.875 | 0.415 | 0.875 | 0.415 | 0.875 | 0.415 | 0.869 | 0.869 |
| 23.200 | 0.874 | 0.868 | 0.874 | 0.412 | 0.874 | 0.412 | 0.874 | 0.412 | 0.868 | 0.868 |
| 25.000 | 0.878 | 0.872 | 0.878 | 0.430 | 0.878 | 0.430 | 0.878 | 0.430 | 0.872 | 0.872 |
| 26.900 | 0.886 | 0.881 | 0.886 | 0.469 | 0.886 | 0.469 | 0.886 | 0.469 | 0.881 | 0.881 |
| 28.500 | 0.881 | 0.875 | 0.881 | 0.443 | 0.881 | 0.443 | 0.881 | 0.443 | 0.875 | 0.875 |
| 30.000 | 0.882 | 0.877 | 0.882 | 0.449 | 0.882 | 0.449 | 0.882 | 0.449 | 0.877 | 0.877 |
| 32.000 | 0.885 | 0.880 | 0.885 | 0.462 | 0.885 | 0.462 | 0.885 | 0.462 | 0.880 | 0.880 |
| 34.000 | 0.889 | 0.883 | 0.889 | 0.478 | 0.889 | 0.478 | 0.889 | 0.478 | 0.883 | 0.883 |
| 35.900 | 0.877 | 0.871 | 0.877 | 0.423 | 0.877 | 0.423 | 0.877 | 0.423 | 0.871 | 0.871 |
| 37.700 | 0.861 | 0.854 | 0.861 | 0.350 | 0.861 | 0.350 | 0.861 | 0.350 | 0.854 | 0.854 |
| 39.500 | 0.872 | 0.866 | 0.872 | 0.403 | 0.872 | 0.403 | 0.872 | 0.403 | 0.866 | 0.866 |
| 41.200 | 0.852 | 0.845 | 0.852 | 0.310 | 0.852 | 0.310 | 0.852 | 0.310 | 0.845 | 0.845 |
| 43.300 | 0.849 | 0.842 | 0.849 | 0.294 | 0.849 | 0.294 | 0.849 | 0.294 | 0.842 | 0.842 |
| 44.700 | 0.854 | 0.847 | 0.854 | 0.319 | 0.854 | 0.319 | 0.854 | 0.319 | 0.847 | 0.847 |
| 46.200 | 0.856 | 0.849 | 0.856 | 0.325 | 0.856 | 0.325 | 0.856 | 0.325 | 0.849 | 0.849 |
| 47.700 | 0.850 | 0.842 | 0.850 | 0.296 | 0.850 | 0.296 | 0.850 | 0.296 | 0.842 | 0.842 |
| 49.700 | 0.860 | 0.853 | 0.860 | 0.344 | 0.860 | 0.344 | 0.860 | 0.344 | 0.853 | 0.853 |
| 51.600 | 0.865 | 0.859 | 0.865 | 0.369 | 0.865 | 0.369 | 0.865 | 0.369 | 0.859 | 0.859 |
| 53.500 | 0.848 | 0.840 | 0.848 | 0.288 | 0.848 | 0.288 | 0.848 | 0.288 | 0.840 | 0.840 |
| 54.900 | 0.842 | 0.834 | 0.842 | 0.258 | 0.842 | 0.258 | 0.842 | 0.258 | 0.834 | 0.834 |
| 56.200 | 0.827 | 0.819 | 0.827 | 0.191 | 0.827 | 0.191 | 0.827 | 0.191 | 0.819 | 0.819 |
| 57.600 | 0.850 | 0.842 | 0.850 | 0.296 | 0.850 | 0.296 | 0.850 | 0.296 | 0.842 | 0.842 |
| 59.800 | 0.891 | 0.886 | 0.891 | 0.491 | 0.891 | 0.491 | 0.891 | 0.491 | 0.886 | 0.886 |
| 61.800 | 0.920 | 0.916 | 0.920 | 0.625 | 0.920 | 0.625 | 0.920 | 0.625 | 0.916 | 0.916 |
| 63.800 | 0.964 | 0.962 | 0.964 | 0.831 | 0.964 | 0.831 | 0.964 | 0.831 | 0.962 | 0.962 |
| 66.500 | 0.966 | 0.964 | 0.966 | 0.839 | 0.966 | 0.839 | 0.966 | 0.839 | 0.964 | 0.964 |
| 68.400 | 0.919 | 0.915 | 0.919 | 0.620 | 0.919 | 0.620 | 0.919 | 0.620 | 0.915 | 0.915 |
| 70.100 | 0.884 | 0.878 | 0.884 | 0.457 | 0.884 | 0.457 | 0.884 | 0.457 | 0.878 | 0.878 |
| 71.600 | 0.873 | 0.867 | 0.873 | 0.406 | 0.873 | 0.406 | 0.873 | 0.406 | 0.867 | 0.867 |
| 73.100 | 0.860 | 0.853 | 0.860 | 0.346 | 0.860 | 0.346 | 0.860 | 0.346 | 0.853 | 0.853 |
| 74.600 | 0.829 | 0.821 | 0.829 | 0.200 | 0.829 | 0.200 | 0.829 | 0.200 | 0.821 | 0.821 |
| 76.200 | 0.813 | 0.804 | 0.813 | 0.124 | 0.813 | 0.124 | 0.813 | 0.124 | 0.804 | 0.804 |
| 78.000 | 0.818 | 0.809 | 0.818 | 0.146 | 0.818 | 0.146 | 0.818 | 0.146 | 0.809 | 0.809 |
| 79.500 | 0.829 | 0.821 | 0.829 | 0.200 | 0.829 | 0.200 | 0.829 | 0.200 | 0.821 | 0.821 |
| 81.600 | 0.839 | 0.831 | 0.839 | 0.246 | 0.839 | 0.246 | 0.839 | 0.246 | 0.831 | 0.831 |
| 83.800 | 0.884 | 0.878 | 0.884 | 0.457 | 0.884 | 0.457 | 0.884 | 0.457 | 0.878 | 0.878 |
| 86.000 | 0.910 | 0.906 | 0.910 | 0.579 | 0.910 | 0.579 | 0.910 | 0.579 | 0.906 | 0.906 |
| 88.100 | 0.945 | 0.942 | 0.945 | 0.741 | 0.945 | 0.741 | 0.945 | 0.741 | 0.942 | 0.942 |
| 89.900 | 0.989 | 0.988 | 0.989 | 0.947 | 0.989 | 0.947 | 0.989 | 0.947 | 0.988 | 0.988 |
| 91.500 | 0.996 | 0.995 | 0.996 | 0.979 | 0.996 | 0.979 | 0.996 | 0.979 | 0.995 | 0.995 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table E.3 (continued)

| GAPXL[a] | VALUE OF K IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.002 | 1.002 | 1.010 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.961 | 0.961 | 0.826 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.920 | 0.920 | 0.642 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.922 | 0.922 | 0.654 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.940 | 0.940 | 0.732 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.973 | 0.973 | 0.880 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.972 | 0.972 | 0.875 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.935 | 0.935 | 0.709 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.912 | 0.912 | 0.606 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.890 | 0.890 | 0.508 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.879 | 0.879 | 0.459 |
| 19.500 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.862 | 0.862 | 0.383 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.869 | 0.869 | 0.415 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.868 | 0.868 | 0.412 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.872 | 0.872 | 0.430 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.881 | 0.881 | 0.469 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.875 | 0.875 | 0.443 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.877 | 0.877 | 0.449 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.880 | 0.880 | 0.462 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.883 | 0.883 | 0.478 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.871 | 0.871 | 0.423 |
| 37.700 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.854 | 0.854 | 0.350 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.866 | 0.866 | 0.403 |
| 41.200 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.845 | 0.845 | 0.310 |
| 43.300 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.842 | 0.842 | 0.294 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.847 | 0.847 | 0.319 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.849 | 0.849 | 0.325 |
| 47.700 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.842 | 0.842 | 0.296 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.853 | 0.853 | 0.344 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.859 | 0.859 | 0.369 |
| 53.500 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.840 | 0.840 | 0.288 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.834 | 0.834 | 0.258 |
| 56.200 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.819 | 0.819 | 0.191 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.842 | 0.842 | 0.296 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.886 | 0.886 | 0.491 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.916 | 0.916 | 0.625 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.962 | 0.962 | 0.831 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.964 | 0.964 | 0.839 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.915 | 0.915 | 0.620 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.878 | 0.457 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.867 | 0.867 | 0.406 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.853 | 0.853 | 0.346 |
| 74.600 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.821 | 0.821 | 0.200 |
| 76.200 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.804 | 0.804 | 0.124 |
| 78.000 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.809 | 0.809 | 0.146 |
| 79.500 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.821 | 0.821 | 0.200 |
| 81.600 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.831 | 0.831 | 0.246 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.878 | 0.457 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.906 | 0.906 | 0.579 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.942 | 0.942 | 0.741 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.988 | 0.988 | 0.947 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.995 | 0.995 | 0.979 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table E.3 (continued)

| GAPXL[a] | VALUE OF K IS: 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.002 | 1.002 | 1.010 | 1.010 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.961 | 0.961 | 0.826 | 0.826 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.920 | 0.920 | 0.642 | 0.642 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.922 | 0.922 | 0.654 | 0.654 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.940 | 0.940 | 0.732 | 0.732 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.973 | 0.973 | 0.880 | 0.880 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.972 | 0.972 | 0.875 | 0.875 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.935 | 0.935 | 0.709 | 0.709 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.912 | 0.912 | 0.606 | 0.606 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.890 | 0.890 | 0.508 | 0.508 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.879 | 0.879 | 0.459 | 0.459 |
| 19.500 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.862 | 0.862 | 0.383 | 0.383 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.869 | 0.869 | 0.415 | 0.415 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.868 | 0.868 | 0.412 | 0.412 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.872 | 0.872 | 0.430 | 0.430 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.881 | 0.881 | 0.469 | 0.469 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.875 | 0.875 | 0.443 | 0.443 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.877 | 0.877 | 0.449 | 0.449 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.880 | 0.880 | 0.462 | 0.462 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.883 | 0.883 | 0.478 | 0.478 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.871 | 0.871 | 0.423 | 0.423 |
| 37.700 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.854 | 0.854 | 0.350 | 0.350 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.866 | 0.866 | 0.403 | 0.403 |
| 41.200 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.845 | 0.845 | 0.310 | 0.310 |
| 43.300 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.842 | 0.842 | 0.294 | 0.294 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.847 | 0.847 | 0.319 | 0.319 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.849 | 0.849 | 0.325 | 0.325 |
| 47.700 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.842 | 0.842 | 0.296 | 0.296 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.853 | 0.853 | 0.344 | 0.344 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.859 | 0.859 | 0.369 | 0.369 |
| 53.500 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.840 | 0.840 | 0.288 | 0.288 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.834 | 0.834 | 0.258 | 0.258 |
| 56.200 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.819 | 0.819 | 0.191 | 0.191 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.842 | 0.842 | 0.296 | 0.296 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.886 | 0.886 | 0.491 | 0.491 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.916 | 0.916 | 0.625 | 0.625 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.962 | 0.962 | 0.831 | 0.831 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.964 | 0.964 | 0.839 | 0.839 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.915 | 0.915 | 0.620 | 0.620 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.878 | 0.457 | 0.457 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.867 | 0.867 | 0.406 | 0.406 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.853 | 0.853 | 0.346 | 0.346 |
| 74.600 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.821 | 0.821 | 0.200 | 0.200 |
| 76.200 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.804 | 0.804 | 0.124 | 0.124 |
| 78.000 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.809 | 0.809 | 0.146 | 0.146 |
| 79.500 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.821 | 0.821 | 0.200 | 0.200 |
| 81.600 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.831 | 0.831 | 0.246 | 0.246 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.878 | 0.457 | 0.457 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.906 | 0.906 | 0.579 | 0.579 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.942 | 0.942 | 0.741 | 0.741 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.988 | 0.988 | 0.947 | 0.947 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.995 | 0.995 | 0.979 | 0.979 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table E.3 (continued)

| GAPXL[a] | VALUE OF K IS: 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.002 | 1.002 | 1.002 | 1.002 | 1.002 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.961 | 0.963 | 0.963 | 0.963 | 0.963 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.920 | 0.923 | 0.923 | 0.923 | 0.923 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.922 | 0.926 | 0.926 | 0.926 | 0.926 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.940 | 0.943 | 0.943 | 0.943 | 0.943 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.973 | 0.974 | 0.974 | 0.974 | 0.974 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.972 | 0.973 | 0.973 | 0.973 | 0.973 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.935 | 0.938 | 0.938 | 0.938 | 0.938 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.912 | 0.916 | 0.916 | 0.916 | 0.916 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.890 | 0.895 | 0.895 | 0.895 | 0.895 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.879 | 0.884 | 0.884 | 0.884 | 0.884 |
| 19.500 | 0.383 | 0.383 | 0.383 | 0.383 | 0.383 | 0.862 | 0.868 | 0.868 | 0.868 | 0.868 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.869 | 0.875 | 0.875 | 0.875 | 0.875 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.868 | 0.874 | 0.874 | 0.874 | 0.874 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.872 | 0.878 | 0.878 | 0.878 | 0.878 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.881 | 0.886 | 0.886 | 0.886 | 0.886 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.875 | 0.881 | 0.881 | 0.881 | 0.881 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.877 | 0.882 | 0.882 | 0.882 | 0.882 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.880 | 0.885 | 0.885 | 0.885 | 0.885 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.883 | 0.889 | 0.889 | 0.889 | 0.889 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.871 | 0.877 | 0.877 | 0.877 | 0.877 |
| 37.700 | 0.350 | 0.350 | 0.350 | 0.350 | 0.350 | 0.854 | 0.861 | 0.861 | 0.861 | 0.861 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.866 | 0.872 | 0.872 | 0.872 | 0.872 |
| 41.200 | 0.310 | 0.310 | 0.310 | 0.310 | 0.310 | 0.845 | 0.852 | 0.852 | 0.852 | 0.852 |
| 43.300 | 0.294 | 0.294 | 0.294 | 0.294 | 0.294 | 0.842 | 0.849 | 0.849 | 0.849 | 0.849 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.847 | 0.854 | 0.854 | 0.854 | 0.854 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.849 | 0.856 | 0.856 | 0.856 | 0.856 |
| 47.700 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.842 | 0.850 | 0.850 | 0.850 | 0.850 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.853 | 0.860 | 0.860 | 0.860 | 0.860 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.859 | 0.865 | 0.865 | 0.865 | 0.865 |
| 53.500 | 0.288 | 0.288 | 0.288 | 0.288 | 0.288 | 0.840 | 0.848 | 0.848 | 0.848 | 0.848 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.834 | 0.842 | 0.842 | 0.842 | 0.842 |
| 56.200 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.819 | 0.827 | 0.827 | 0.827 | 0.827 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.842 | 0.850 | 0.850 | 0.850 | 0.850 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.886 | 0.891 | 0.891 | 0.891 | 0.891 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.916 | 0.920 | 0.920 | 0.920 | 0.920 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.962 | 0.964 | 0.964 | 0.964 | 0.964 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.964 | 0.966 | 0.966 | 0.966 | 0.966 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.915 | 0.919 | 0.919 | 0.919 | 0.919 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.884 | 0.884 | 0.884 | 0.884 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.867 | 0.873 | 0.873 | 0.873 | 0.873 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.853 | 0.860 | 0.860 | 0.860 | 0.860 |
| 74.600 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.821 | 0.829 | 0.829 | 0.829 | 0.829 |
| 76.200 | 0.124 | 0.124 | 0.124 | 0.124 | 0.124 | 0.804 | 0.813 | 0.813 | 0.813 | 0.813 |
| 78.000 | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 | 0.809 | 0.818 | 0.818 | 0.818 | 0.818 |
| 79.500 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 | 0.821 | 0.829 | 0.829 | 0.829 | 0.829 |
| 81.600 | 0.246 | 0.246 | 0.246 | 0.246 | 0.246 | 0.831 | 0.839 | 0.839 | 0.839 | 0.839 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.884 | 0.884 | 0.884 | 0.884 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.906 | 0.910 | 0.910 | 0.910 | 0.910 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.942 | 0.945 | 0.945 | 0.945 | 0.945 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.988 | 0.989 | 0.989 | 0.989 | 0.989 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.995 | 0.996 | 0.996 | 0.996 | 0.996 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]GAPXL values are the centimeters from the bottom of the heated zone.

# Appendix F

## B-2/SHROUD 2 BUNDLE-AVERAGED GEOMETRY DATA, MAXIMUM RESTRICTION DEFINITION

The data in Appendix F represent the input from card groups 5 and 6 as required by ref. 2 for the B-2/shroud 2 COBRA-IV model based on the maximum restriction definition.

Table F.1. Shroud flow area reductions for the B-2/shroud 2 COBRA-IV model based on the maximum restriction definition

| AXL[a] | FRACTIONAL SHROUD FLOW AREA |
|---|---|
| -47.676 | 1.000 |
| 0.000 | 1.003 |
| 1.800 | 0.950 |
| 3.400 | 0.894 |
| 5.000 | 0.898 |
| 6.900 | 0.922 |
| 8.800 | 0.966 |
| 11.500 | 0.964 |
| 13.300 | 0.915 |
| 15.100 | 0.883 |
| 16.800 | 0.851 |
| 18.100 | 0.835 |
| 19.500 | 0.797 |
| 21.400 | 0.821 |
| 23.200 | 0.820 |
| 25.000 | 0.826 |
| 26.900 | 0.838 |
| 28.500 | 0.830 |
| 30.000 | 0.832 |
| 32.000 | 0.836 |
| 34.000 | 0.842 |
| 35.900 | 0.823 |
| 37.700 | 0.794 |
| 39.500 | 0.817 |
| 41.200 | 0.766 |
| 43.300 | 0.756 |
| 44.700 | 0.788 |
| 46.200 | 0.790 |
| 47.700 | 0.770 |
| 49.700 | 0.797 |
| 51.600 | 0.805 |
| 53.500 | 0.751 |
| 54.900 | 0.767 |
| 56.200 | 0.700 |
| 57.600 | 0.780 |
| 59.800 | 0.846 |
| 61.800 | 0.889 |
| 63.800 | 0.951 |
| 66.500 | 0.954 |
| 68.400 | 0.887 |
| 70.100 | 0.835 |
| 71.600 | 0.818 |
| 73.100 | 0.797 |
| 74.600 | 0.739 |
| 76.200 | 0.661 |
| 78.000 | 0.715 |
| 79.500 | 0.742 |
| 81.600 | 0.730 |
| 83.800 | 0.835 |
| 86.000 | 0.874 |
| 88.100 | 0.924 |
| 89.900 | 0.985 |
| 91.500 | 0.994 |
| 95.987 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table F.2. AFACT values for the B-2/shroud 2 COBRA-IV model based on the maximum restriction definition

| AXL[a] VALUE OF I IS: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.001 | 1.002 | 1.002 | 1.002 | 1.001 | 1.002 | 1.005 | 1.005 | 1.005 | 1.002 |
| 1.800 | 0.983 | 0.964 | 0.964 | 0.964 | 0.983 | 0.963 | 0.906 | 0.906 | 0.906 | 0.963 |
| 3.400 | 0.964 | 0.924 | 0.924 | 0.924 | 0.964 | 0.921 | 0.801 | 0.801 | 0.801 | 0.921 |
| 5.000 | 0.965 | 0.927 | 0.927 | 0.927 | 0.965 | 0.924 | 0.808 | 0.808 | 0.808 | 0.924 |
| 6.900 | 0.973 | 0.944 | 0.944 | 0.944 | 0.973 | 0.942 | 0.853 | 0.853 | 0.853 | 0.942 |
| 8.800 | 0.988 | 0.976 | 0.976 | 0.976 | 0.988 | 0.975 | 0.936 | 0.936 | 0.936 | 0.975 |
| 11.500 | 0.988 | 0.974 | 0.974 | 0.974 | 0.988 | 0.974 | 0.933 | 0.933 | 0.933 | 0.974 |
| 13.300 | 0.971 | 0.939 | 0.939 | 0.939 | 0.971 | 0.937 | 0.840 | 0.840 | 0.840 | 0.937 |
| 15.100 | 0.960 | 0.916 | 0.916 | 0.916 | 0.960 | 0.913 | 0.780 | 0.780 | 0.780 | 0.913 |
| 16.800 | 0.950 | 0.894 | 0.894 | 0.894 | 0.950 | 0.890 | 0.721 | 0.721 | 0.721 | 0.890 |
| 18.100 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 | 0.878 | 0.691 | 0.691 | 0.691 | 0.878 |
| 19.500 | 0.931 | 0.855 | 0.855 | 0.855 | 0.931 | 0.850 | 0.620 | 0.620 | 0.620 | 0.850 |
| 21.400 | 0.939 | 0.872 | 0.872 | 0.872 | 0.939 | 0.867 | 0.664 | 0.664 | 0.664 | 0.867 |
| 23.200 | 0.939 | 0.871 | 0.871 | 0.871 | 0.939 | 0.866 | 0.662 | 0.662 | 0.662 | 0.866 |
| 25.000 | 0.941 | 0.876 | 0.876 | 0.876 | 0.941 | 0.871 | 0.673 | 0.673 | 0.673 | 0.871 |
| 26.900 | 0.945 | 0.885 | 0.885 | 0.885 | 0.945 | 0.880 | 0.697 | 0.697 | 0.697 | 0.880 |
| 28.500 | 0.942 | 0.879 | 0.879 | 0.879 | 0.942 | 0.874 | 0.681 | 0.681 | 0.681 | 0.874 |
| 30.000 | 0.943 | 0.880 | 0.880 | 0.880 | 0.943 | 0.876 | 0.685 | 0.685 | 0.685 | 0.876 |
| 32.000 | 0.944 | 0.883 | 0.883 | 0.883 | 0.944 | 0.879 | 0.693 | 0.693 | 0.693 | 0.879 |
| 34.000 | 0.946 | 0.887 | 0.887 | 0.887 | 0.946 | 0.883 | 0.703 | 0.703 | 0.703 | 0.883 |
| 35.900 | 0.940 | 0.874 | 0.874 | 0.874 | 0.940 | 0.869 | 0.669 | 0.669 | 0.669 | 0.869 |
| 37.700 | 0.930 | 0.853 | 0.853 | 0.853 | 0.930 | 0.847 | 0.614 | 0.614 | 0.614 | 0.847 |
| 39.500 | 0.938 | 0.869 | 0.869 | 0.869 | 0.938 | 0.864 | 0.656 | 0.656 | 0.656 | 0.864 |
| 41.200 | 0.921 | 0.833 | 0.833 | 0.833 | 0.921 | 0.827 | 0.561 | 0.561 | 0.561 | 0.827 |
| 43.300 | 0.917 | 0.826 | 0.826 | 0.826 | 0.917 | 0.819 | 0.542 | 0.542 | 0.542 | 0.819 |
| 44.700 | 0.928 | 0.849 | 0.849 | 0.849 | 0.928 | 0.843 | 0.603 | 0.603 | 0.603 | 0.843 |
| 46.200 | 0.929 | 0.850 | 0.850 | 0.850 | 0.929 | 0.845 | 0.607 | 0.607 | 0.607 | 0.845 |
| 47.700 | 0.922 | 0.836 | 0.836 | 0.836 | 0.922 | 0.830 | 0.569 | 0.569 | 0.569 | 0.830 |
| 49.700 | 0.931 | 0.855 | 0.855 | 0.855 | 0.931 | 0.849 | 0.619 | 0.619 | 0.619 | 0.849 |
| 51.600 | 0.934 | 0.861 | 0.861 | 0.861 | 0.934 | 0.856 | 0.635 | 0.635 | 0.635 | 0.856 |
| 53.500 | 0.916 | 0.823 | 0.823 | 0.823 | 0.916 | 0.816 | 0.534 | 0.534 | 0.534 | 0.816 |
| 54.900 | 0.921 | 0.834 | 0.834 | 0.834 | 0.921 | 0.828 | 0.564 | 0.564 | 0.564 | 0.828 |
| 56.200 | 0.898 | 0.786 | 0.786 | 0.786 | 0.898 | 0.778 | 0.438 | 0.438 | 0.438 | 0.778 |
| 57.600 | 0.925 | 0.843 | 0.843 | 0.843 | 0.925 | 0.837 | 0.588 | 0.588 | 0.588 | 0.837 |
| 59.800 | 0.948 | 0.890 | 0.890 | 0.890 | 0.948 | 0.886 | 0.711 | 0.711 | 0.711 | 0.886 |
| 61.800 | 0.962 | 0.920 | 0.920 | 0.920 | 0.962 | 0.917 | 0.791 | 0.791 | 0.791 | 0.917 |
| 63.800 | 0.984 | 0.965 | 0.965 | 0.965 | 0.984 | 0.964 | 0.909 | 0.909 | 0.909 | 0.964 |
| 66.500 | 0.984 | 0.967 | 0.967 | 0.967 | 0.984 | 0.966 | 0.913 | 0.913 | 0.913 | 0.966 |
| 68.400 | 0.962 | 0.919 | 0.919 | 0.919 | 0.962 | 0.916 | 0.788 | 0.788 | 0.788 | 0.916 |
| 70.100 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 |
| 71.600 | 0.938 | 0.870 | 0.870 | 0.870 | 0.938 | 0.865 | 0.658 | 0.658 | 0.658 | 0.865 |
| 73.100 | 0.931 | 0.855 | 0.855 | 0.855 | 0.931 | 0.850 | 0.620 | 0.620 | 0.620 | 0.850 |
| 74.600 | 0.912 | 0.814 | 0.814 | 0.814 | 0.912 | 0.807 | 0.511 | 0.511 | 0.511 | 0.807 |
| 76.200 | 0.885 | 0.758 | 0.758 | 0.758 | 0.885 | 0.749 | 0.364 | 0.364 | 0.364 | 0.749 |
| 78.000 | 0.903 | 0.796 | 0.796 | 0.796 | 0.903 | 0.789 | 0.465 | 0.465 | 0.465 | 0.789 |
| 79.500 | 0.912 | 0.816 | 0.816 | 0.816 | 0.912 | 0.809 | 0.516 | 0.516 | 0.516 | 0.809 |
| 81.600 | 0.908 | 0.807 | 0.807 | 0.807 | 0.908 | 0.800 | 0.494 | 0.494 | 0.494 | 0.800 |
| 83.800 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 |
| 86.000 | 0.957 | 0.910 | 0.910 | 0.910 | 0.957 | 0.907 | 0.764 | 0.764 | 0.764 | 0.907 |
| 88.100 | 0.974 | 0.946 | 0.946 | 0.946 | 0.974 | 0.944 | 0.858 | 0.858 | 0.858 | 0.944 |
| 89.900 | 0.995 | 0.989 | 0.989 | 0.989 | 0.995 | 0.989 | 0.972 | 0.972 | 0.972 | 0.989 |
| 91.500 | 0.998 | 0.996 | 0.996 | 0.996 | 0.998 | 0.996 | 0.989 | 0.989 | 0.989 | 0.996 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table F.2 (continued)

| AXL[a] | VALUE OF I IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.002 | 1.005 | 1.005 | 1.005 | 1.002 | 1.002 | 1.005 | 1.005 | 1.005 | 1.002 |
| 1.800 | 0.963 | 0.906 | 0.906 | 0.906 | 0.963 | 0.963 | 0.906 | 0.906 | 0.906 | 0.963 |
| 3.400 | 0.921 | 0.801 | 0.801 | 0.801 | 0.921 | 0.921 | 0.801 | 0.801 | 0.801 | 0.921 |
| 5.000 | 0.924 | 0.808 | 0.808 | 0.808 | 0.924 | 0.924 | 0.808 | 0.808 | 0.808 | 0.924 |
| 6.900 | 0.942 | 0.853 | 0.853 | 0.853 | 0.942 | 0.942 | 0.853 | 0.853 | 0.853 | 0.942 |
| 8.800 | 0.975 | 0.936 | 0.936 | 0.936 | 0.975 | 0.975 | 0.936 | 0.936 | 0.936 | 0.975 |
| 11.500 | 0.974 | 0.933 | 0.933 | 0.933 | 0.974 | 0.974 | 0.933 | 0.933 | 0.933 | 0.974 |
| 13.300 | 0.937 | 0.840 | 0.840 | 0.840 | 0.937 | 0.937 | 0.840 | 0.840 | 0.840 | 0.937 |
| 15.100 | 0.913 | 0.780 | 0.780 | 0.780 | 0.913 | 0.913 | 0.780 | 0.780 | 0.780 | 0.913 |
| 16.800 | 0.890 | 0.721 | 0.721 | 0.721 | 0.890 | 0.890 | 0.721 | 0.721 | 0.721 | 0.890 |
| 18.100 | 0.878 | 0.691 | 0.691 | 0.691 | 0.878 | 0.878 | 0.691 | 0.691 | 0.691 | 0.878 |
| 19.500 | 0.850 | 0.620 | 0.620 | 0.620 | 0.850 | 0.850 | 0.620 | 0.620 | 0.620 | 0.850 |
| 21.400 | 0.867 | 0.664 | 0.664 | 0.664 | 0.867 | 0.867 | 0.664 | 0.664 | 0.664 | 0.867 |
| 23.200 | 0.866 | 0.662 | 0.662 | 0.662 | 0.866 | 0.866 | 0.662 | 0.662 | 0.662 | 0.866 |
| 25.000 | 0.871 | 0.673 | 0.673 | 0.673 | 0.871 | 0.871 | 0.673 | 0.673 | 0.673 | 0.871 |
| 26.900 | 0.880 | 0.697 | 0.697 | 0.697 | 0.880 | 0.880 | 0.697 | 0.697 | 0.697 | 0.880 |
| 28.500 | 0.874 | 0.681 | 0.681 | 0.681 | 0.874 | 0.874 | 0.681 | 0.681 | 0.681 | 0.874 |
| 30.000 | 0.876 | 0.685 | 0.685 | 0.685 | 0.876 | 0.876 | 0.685 | 0.685 | 0.685 | 0.876 |
| 32.000 | 0.879 | 0.693 | 0.693 | 0.693 | 0.879 | 0.879 | 0.693 | 0.693 | 0.693 | 0.879 |
| 34.000 | 0.883 | 0.703 | 0.703 | 0.703 | 0.883 | 0.883 | 0.703 | 0.703 | 0.703 | 0.883 |
| 35.900 | 0.869 | 0.669 | 0.669 | 0.669 | 0.869 | 0.869 | 0.669 | 0.669 | 0.669 | 0.869 |
| 37.700 | 0.847 | 0.614 | 0.614 | 0.614 | 0.847 | 0.847 | 0.614 | 0.614 | 0.614 | 0.847 |
| 39.500 | 0.864 | 0.656 | 0.656 | 0.656 | 0.864 | 0.864 | 0.656 | 0.656 | 0.656 | 0.864 |
| 41.200 | 0.827 | 0.561 | 0.561 | 0.561 | 0.827 | 0.827 | 0.561 | 0.561 | 0.561 | 0.827 |
| 43.300 | 0.819 | 0.542 | 0.542 | 0.542 | 0.819 | 0.819 | 0.542 | 0.542 | 0.542 | 0.819 |
| 44.700 | 0.843 | 0.603 | 0.603 | 0.603 | 0.843 | 0.843 | 0.603 | 0.603 | 0.603 | 0.843 |
| 46.200 | 0.845 | 0.607 | 0.607 | 0.607 | 0.845 | 0.845 | 0.607 | 0.607 | 0.607 | 0.845 |
| 47.700 | 0.830 | 0.569 | 0.569 | 0.569 | 0.830 | 0.830 | 0.569 | 0.569 | 0.569 | 0.830 |
| 49.700 | 0.849 | 0.619 | 0.619 | 0.619 | 0.849 | 0.849 | 0.619 | 0.619 | 0.619 | 0.849 |
| 51.600 | 0.856 | 0.635 | 0.635 | 0.635 | 0.856 | 0.856 | 0.635 | 0.635 | 0.635 | 0.856 |
| 53.500 | 0.816 | 0.534 | 0.534 | 0.534 | 0.816 | 0.816 | 0.534 | 0.534 | 0.534 | 0.816 |
| 54.900 | 0.828 | 0.564 | 0.564 | 0.564 | 0.828 | 0.828 | 0.564 | 0.564 | 0.564 | 0.828 |
| 56.200 | 0.778 | 0.438 | 0.438 | 0.438 | 0.778 | 0.778 | 0.438 | 0.438 | 0.438 | 0.778 |
| 57.600 | 0.837 | 0.588 | 0.588 | 0.588 | 0.837 | 0.837 | 0.588 | 0.588 | 0.588 | 0.837 |
| 59.800 | 0.886 | 0.711 | 0.711 | 0.711 | 0.886 | 0.886 | 0.711 | 0.711 | 0.711 | 0.886 |
| 61.800 | 0.917 | 0.791 | 0.791 | 0.791 | 0.917 | 0.917 | 0.791 | 0.791 | 0.791 | 0.917 |
| 63.800 | 0.964 | 0.909 | 0.909 | 0.909 | 0.964 | 0.964 | 0.909 | 0.909 | 0.909 | 0.964 |
| 66.500 | 0.966 | 0.913 | 0.913 | 0.913 | 0.966 | 0.966 | 0.913 | 0.913 | 0.913 | 0.966 |
| 68.400 | 0.916 | 0.788 | 0.788 | 0.788 | 0.916 | 0.916 | 0.788 | 0.788 | 0.788 | 0.916 |
| 70.100 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 |
| 71.600 | 0.865 | 0.658 | 0.658 | 0.658 | 0.865 | 0.865 | 0.658 | 0.658 | 0.658 | 0.865 |
| 73.100 | 0.850 | 0.620 | 0.620 | 0.620 | 0.850 | 0.850 | 0.620 | 0.620 | 0.620 | 0.850 |
| 74.600 | 0.807 | 0.511 | 0.511 | 0.511 | 0.807 | 0.807 | 0.511 | 0.511 | 0.511 | 0.807 |
| 76.200 | 0.749 | 0.364 | 0.364 | 0.364 | 0.749 | 0.749 | 0.364 | 0.364 | 0.364 | 0.749 |
| 78.000 | 0.789 | 0.465 | 0.465 | 0.465 | 0.789 | 0.789 | 0.465 | 0.465 | 0.465 | 0.789 |
| 79.500 | 0.809 | 0.516 | 0.516 | 0.516 | 0.809 | 0.809 | 0.516 | 0.516 | 0.516 | 0.809 |
| 81.600 | 0.800 | 0.494 | 0.494 | 0.494 | 0.800 | 0.800 | 0.494 | 0.494 | 0.494 | 0.800 |
| 83.800 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 | 0.878 | 0.690 | 0.690 | 0.690 | 0.878 |
| 86.000 | 0.907 | 0.764 | 0.764 | 0.764 | 0.907 | 0.907 | 0.764 | 0.764 | 0.764 | 0.907 |
| 88.100 | 0.944 | 0.858 | 0.858 | 0.858 | 0.944 | 0.944 | 0.858 | 0.858 | 0.858 | 0.944 |
| 89.900 | 0.989 | 0.972 | 0.972 | 0.972 | 0.989 | 0.989 | 0.972 | 0.972 | 0.972 | 0.989 |
| 91.500 | 0.996 | 0.989 | 0.989 | 0.989 | 0.996 | 0.996 | 0.989 | 0.989 | 0.989 | 0.996 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table F.2 (continued)

| AXL[a] | VALUE OF I IS: 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.001 | 1.002 | 1.002 | 1.002 | 1.001 |
| 1.800 | 0.983 | 0.964 | 0.964 | 0.964 | 0.983 |
| 3.400 | 0.964 | 0.924 | 0.924 | 0.924 | 0.964 |
| 5.000 | 0.965 | 0.927 | 0.927 | 0.927 | 0.965 |
| 6.900 | 0.973 | 0.944 | 0.944 | 0.944 | 0.973 |
| 8.800 | 0.988 | 0.976 | 0.976 | 0.976 | 0.988 |
| 11.500 | 0.988 | 0.974 | 0.974 | 0.974 | 0.988 |
| 13.300 | 0.971 | 0.939 | 0.939 | 0.939 | 0.971 |
| 15.100 | 0.960 | 0.916 | 0.916 | 0.916 | 0.960 |
| 16.800 | 0.950 | 0.894 | 0.894 | 0.894 | 0.950 |
| 18.100 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 |
| 19.500 | 0.931 | 0.855 | 0.855 | 0.855 | 0.931 |
| 21.400 | 0.939 | 0.872 | 0.872 | 0.872 | 0.939 |
| 23.200 | 0.939 | 0.871 | 0.871 | 0.871 | 0.939 |
| 25.000 | 0.941 | 0.876 | 0.876 | 0.876 | 0.941 |
| 26.900 | 0.945 | 0.885 | 0.885 | 0.885 | 0.945 |
| 28.500 | 0.942 | 0.879 | 0.879 | 0.879 | 0.942 |
| 30.000 | 0.943 | 0.880 | 0.880 | 0.880 | 0.943 |
| 32.000 | 0.944 | 0.883 | 0.883 | 0.883 | 0.944 |
| 34.000 | 0.946 | 0.887 | 0.887 | 0.887 | 0.946 |
| 35.900 | 0.940 | 0.874 | 0.874 | 0.874 | 0.940 |
| 37.700 | 0.930 | 0.853 | 0.853 | 0.853 | 0.930 |
| 39.500 | 0.938 | 0.869 | 0.869 | 0.869 | 0.938 |
| 41.200 | 0.921 | 0.833 | 0.833 | 0.833 | 0.921 |
| 43.300 | 0.917 | 0.826 | 0.826 | 0.826 | 0.917 |
| 44.700 | 0.928 | 0.849 | 0.849 | 0.849 | 0.928 |
| 46.200 | 0.929 | 0.850 | 0.850 | 0.850 | 0.929 |
| 47.700 | 0.922 | 0.836 | 0.836 | 0.836 | 0.922 |
| 49.700 | 0.931 | 0.855 | 0.855 | 0.855 | 0.931 |
| 51.600 | 0.934 | 0.861 | 0.861 | 0.861 | 0.934 |
| 53.500 | 0.916 | 0.823 | 0.823 | 0.823 | 0.916 |
| 54.900 | 0.921 | 0.834 | 0.834 | 0.834 | 0.921 |
| 56.200 | 0.898 | 0.786 | 0.786 | 0.786 | 0.898 |
| 57.600 | 0.925 | 0.843 | 0.843 | 0.843 | 0.925 |
| 59.800 | 0.948 | 0.890 | 0.890 | 0.890 | 0.948 |
| 61.800 | 0.962 | 0.920 | 0.920 | 0.920 | 0.962 |
| 63.800 | 0.984 | 0.965 | 0.965 | 0.965 | 0.984 |
| 66.500 | 0.984 | 0.967 | 0.967 | 0.967 | 0.984 |
| 68.400 | 0.962 | 0.919 | 0.919 | 0.919 | 0.962 |
| 70.100 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 |
| 71.600 | 0.938 | 0.870 | 0.870 | 0.870 | 0.938 |
| 73.100 | 0.931 | 0.855 | 0.855 | 0.855 | 0.931 |
| 74.600 | 0.912 | 0.814 | 0.814 | 0.814 | 0.912 |
| 76.200 | 0.885 | 0.758 | 0.758 | 0.758 | 0.885 |
| 78.000 | 0.903 | 0.796 | 0.796 | 0.796 | 0.903 |
| 79.500 | 0.912 | 0.816 | 0.816 | 0.816 | 0.912 |
| 81.600 | 0.908 | 0.807 | 0.807 | 0.807 | 0.908 |
| 83.800 | 0.944 | 0.882 | 0.882 | 0.882 | 0.944 |
| 86.000 | 0.957 | 0.910 | 0.910 | 0.910 | 0.957 |
| 88.100 | 0.974 | 0.946 | 0.946 | 0.946 | 0.974 |
| 89.900 | 0.995 | 0.989 | 0.989 | 0.989 | 0.995 |
| 91.500 | 0.998 | 0.996 | 0.996 | 0.996 | 0.998 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]AXL values are the centimeters from the bottom of the heated zone.

Table F.3. GFACT values for the B-2/shroud 2 COBRA-IV model based on the maximum restriction definition

| GAPXL[a] | VALUE OF K IS: 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.002 | 1.002 | 1.002 | 1.010 | 1.002 | 1.010 | 1.002 | 1.010 | 1.002 | 1.002 |
| 1.800 | 0.963 | 0.961 | 0.963 | 0.826 | 0.963 | 0.826 | 0.963 | 0.826 | 0.961 | 0.961 |
| 3.400 | 0.923 | 0.920 | 0.923 | 0.642 | 0.923 | 0.642 | 0.923 | 0.642 | 0.920 | 0.920 |
| 5.000 | 0.926 | 0.922 | 0.926 | 0.654 | 0.926 | 0.654 | 0.926 | 0.654 | 0.922 | 0.922 |
| 6.900 | 0.943 | 0.940 | 0.943 | 0.732 | 0.943 | 0.732 | 0.943 | 0.732 | 0.940 | 0.940 |
| 8.800 | 0.974 | 0.973 | 0.974 | 0.880 | 0.974 | 0.880 | 0.974 | 0.880 | 0.973 | 0.973 |
| 11.500 | 0.973 | 0.972 | 0.973 | 0.875 | 0.973 | 0.875 | 0.973 | 0.875 | 0.972 | 0.972 |
| 13.300 | 0.938 | 0.935 | 0.938 | 0.709 | 0.938 | 0.709 | 0.938 | 0.709 | 0.935 | 0.935 |
| 15.100 | 0.916 | 0.912 | 0.916 | 0.606 | 0.916 | 0.606 | 0.916 | 0.606 | 0.912 | 0.912 |
| 16.800 | 0.895 | 0.890 | 0.895 | 0.508 | 0.895 | 0.508 | 0.895 | 0.508 | 0.890 | 0.890 |
| 18.100 | 0.884 | 0.879 | 0.884 | 0.459 | 0.884 | 0.459 | 0.884 | 0.459 | 0.879 | 0.879 |
| 19.500 | 0.860 | 0.853 | 0.860 | 0.346 | 0.860 | 0.346 | 0.860 | 0.346 | 0.853 | 0.853 |
| 21.400 | 0.875 | 0.869 | 0.875 | 0.415 | 0.875 | 0.415 | 0.875 | 0.415 | 0.869 | 0.869 |
| 23.200 | 0.874 | 0.868 | 0.874 | 0.412 | 0.874 | 0.412 | 0.874 | 0.412 | 0.868 | 0.868 |
| 25.000 | 0.878 | 0.872 | 0.878 | 0.430 | 0.878 | 0.430 | 0.878 | 0.430 | 0.872 | 0.872 |
| 26.900 | 0.886 | 0.881 | 0.886 | 0.469 | 0.886 | 0.469 | 0.886 | 0.469 | 0.881 | 0.881 |
| 28.500 | 0.881 | 0.875 | 0.881 | 0.443 | 0.881 | 0.443 | 0.881 | 0.443 | 0.875 | 0.875 |
| 30.000 | 0.882 | 0.877 | 0.882 | 0.449 | 0.882 | 0.449 | 0.882 | 0.449 | 0.877 | 0.877 |
| 32.000 | 0.885 | 0.880 | 0.885 | 0.462 | 0.885 | 0.462 | 0.885 | 0.462 | 0.880 | 0.880 |
| 34.000 | 0.889 | 0.883 | 0.889 | 0.478 | 0.889 | 0.478 | 0.889 | 0.478 | 0.883 | 0.883 |
| 35.900 | 0.877 | 0.871 | 0.877 | 0.423 | 0.877 | 0.423 | 0.877 | 0.423 | 0.871 | 0.871 |
| 37.700 | 0.858 | 0.851 | 0.858 | 0.336 | 0.858 | 0.336 | 0.858 | 0.336 | 0.851 | 0.851 |
| 39.500 | 0.872 | 0.866 | 0.872 | 0.403 | 0.872 | 0.403 | 0.872 | 0.403 | 0.866 | 0.866 |
| 41.200 | 0.841 | 0.833 | 0.841 | 0.254 | 0.841 | 0.254 | 0.841 | 0.254 | 0.833 | 0.833 |
| 43.300 | 0.834 | 0.826 | 0.834 | 0.225 | 0.834 | 0.225 | 0.834 | 0.225 | 0.826 | 0.826 |
| 44.700 | 0.854 | 0.847 | 0.854 | 0.319 | 0.854 | 0.319 | 0.854 | 0.319 | 0.847 | 0.847 |
| 46.200 | 0.856 | 0.849 | 0.856 | 0.325 | 0.856 | 0.325 | 0.856 | 0.325 | 0.849 | 0.849 |
| 47.700 | 0.843 | 0.836 | 0.843 | 0.266 | 0.843 | 0.266 | 0.843 | 0.266 | 0.836 | 0.836 |
| 49.700 | 0.860 | 0.853 | 0.860 | 0.344 | 0.860 | 0.344 | 0.860 | 0.344 | 0.853 | 0.853 |
| 51.600 | 0.865 | 0.859 | 0.865 | 0.369 | 0.865 | 0.369 | 0.865 | 0.369 | 0.859 | 0.859 |
| 53.500 | 0.832 | 0.824 | 0.832 | 0.213 | 0.832 | 0.213 | 0.832 | 0.213 | 0.824 | 0.824 |
| 54.900 | 0.842 | 0.834 | 0.842 | 0.258 | 0.842 | 0.258 | 0.842 | 0.258 | 0.834 | 0.834 |
| 56.200 | 0.801 | 0.792 | 0.801 | 0.069 | 0.801 | 0.069 | 0.801 | 0.069 | 0.792 | 0.792 |
| 57.600 | 0.850 | 0.842 | 0.850 | 0.296 | 0.850 | 0.296 | 0.850 | 0.296 | 0.842 | 0.842 |
| 59.800 | 0.891 | 0.886 | 0.891 | 0.491 | 0.891 | 0.491 | 0.891 | 0.491 | 0.886 | 0.886 |
| 61.800 | 0.920 | 0.916 | 0.920 | 0.625 | 0.920 | 0.625 | 0.920 | 0.625 | 0.916 | 0.916 |
| 63.800 | 0.964 | 0.962 | 0.964 | 0.831 | 0.964 | 0.831 | 0.964 | 0.831 | 0.962 | 0.962 |
| 66.500 | 0.966 | 0.964 | 0.966 | 0.839 | 0.966 | 0.839 | 0.966 | 0.839 | 0.964 | 0.964 |
| 68.400 | 0.919 | 0.915 | 0.919 | 0.620 | 0.919 | 0.620 | 0.919 | 0.620 | 0.915 | 0.915 |
| 70.100 | 0.884 | 0.878 | 0.884 | 0.457 | 0.884 | 0.457 | 0.884 | 0.457 | 0.878 | 0.878 |
| 71.600 | 0.873 | 0.867 | 0.873 | 0.406 | 0.873 | 0.406 | 0.873 | 0.406 | 0.867 | 0.867 |
| 73.100 | 0.860 | 0.853 | 0.860 | 0.346 | 0.860 | 0.346 | 0.860 | 0.346 | 0.853 | 0.853 |
| 74.600 | 0.824 | 0.816 | 0.824 | 0.178 | 0.824 | 0.178 | 0.824 | 0.178 | 0.816 | 0.816 |
| 76.200 | 0.778 | 0.768 | 0.778 | 0.0 | 0.778 | 0.0 | 0.778 | 0.0 | 0.768 | 0.768 |
| 78.000 | 0.810 | 0.800 | 0.810 | 0.109 | 0.810 | 0.109 | 0.810 | 0.109 | 0.800 | 0.800 |
| 79.500 | 0.826 | 0.817 | 0.826 | 0.185 | 0.826 | 0.185 | 0.826 | 0.185 | 0.817 | 0.817 |
| 81.600 | 0.819 | 0.810 | 0.819 | 0.152 | 0.819 | 0.152 | 0.819 | 0.152 | 0.810 | 0.810 |
| 83.800 | 0.884 | 0.878 | 0.884 | 0.457 | 0.884 | 0.457 | 0.884 | 0.457 | 0.878 | 0.878 |
| 86.000 | 0.910 | 0.906 | 0.910 | 0.579 | 0.910 | 0.579 | 0.910 | 0.579 | 0.906 | 0.906 |
| 88.100 | 0.945 | 0.942 | 0.945 | 0.741 | 0.945 | 0.741 | 0.945 | 0.741 | 0.942 | 0.942 |
| 89.900 | 0.989 | 0.988 | 0.989 | 0.947 | 0.989 | 0.947 | 0.989 | 0.947 | 0.988 | 0.988 |
| 91.500 | 0.996 | 0.995 | 0.996 | 0.979 | 0.996 | 0.979 | 0.996 | 0.979 | 0.995 | 0.995 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table F.3 (continued)

| GAPXL[a] | VALUE OF K IS: 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.002 | 1.002 | 1.010 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.961 | 0.961 | 0.826 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.920 | 0.920 | 0.642 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.922 | 0.922 | 0.654 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.940 | 0.940 | 0.732 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.973 | 0.973 | 0.880 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.972 | 0.972 | 0.875 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.935 | 0.935 | 0.709 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.912 | 0.912 | 0.606 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.890 | 0.890 | 0.508 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.879 | 0.879 | 0.459 |
| 19.500 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.853 | 0.853 | 0.346 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.869 | 0.869 | 0.415 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.868 | 0.868 | 0.412 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.872 | 0.872 | 0.430 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.881 | 0.881 | 0.469 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.875 | 0.875 | 0.443 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.877 | 0.877 | 0.449 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.880 | 0.880 | 0.462 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.883 | 0.883 | 0.478 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.871 | 0.871 | 0.423 |
| 37.700 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.851 | 0.851 | 0.336 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.866 | 0.866 | 0.403 |
| 41.200 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.833 | 0.833 | 0.254 |
| 43.300 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.826 | 0.826 | 0.225 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.847 | 0.847 | 0.319 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.849 | 0.849 | 0.325 |
| 47.700 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.836 | 0.836 | 0.266 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.853 | 0.853 | 0.344 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.859 | 0.859 | 0.369 |
| 53.500 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.824 | 0.824 | 0.213 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.834 | 0.834 | 0.258 |
| 56.200 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.792 | 0.792 | 0.069 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.842 | 0.842 | 0.296 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.886 | 0.886 | 0.491 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.916 | 0.916 | 0.625 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.962 | 0.962 | 0.831 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.964 | 0.964 | 0.839 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.915 | 0.915 | 0.620 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.878 | 0.457 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.867 | 0.867 | 0.406 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.853 | 0.853 | 0.346 |
| 74.600 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.816 | 0.816 | 0.178 |
| 76.200 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.768 | 0.768 | 0.0 |
| 78.000 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.800 | 0.800 | 0.109 |
| 79.500 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.817 | 0.817 | 0.185 |
| 81.600 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.810 | 0.810 | 0.152 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.878 | 0.457 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.906 | 0.906 | 0.579 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.942 | 0.942 | 0.741 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.988 | 0.988 | 0.947 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.995 | 0.995 | 0.979 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table F.3 (continued)

| GAPXL[a] | VALUE OF K IS: 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.002 | 1.002 | 1.010 | 1.010 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.961 | 0.961 | 0.826 | 0.826 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.920 | 0.920 | 0.642 | 0.642 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.922 | 0.922 | 0.654 | 0.654 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.940 | 0.940 | 0.732 | 0.732 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.973 | 0.973 | 0.880 | 0.880 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.972 | 0.972 | 0.875 | 0.875 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.935 | 0.935 | 0.709 | 0.709 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.912 | 0.912 | 0.606 | 0.606 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.890 | 0.890 | 0.508 | 0.508 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.879 | 0.879 | 0.459 | 0.459 |
| 19.500 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.853 | 0.853 | 0.346 | 0.346 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.869 | 0.869 | 0.415 | 0.415 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.868 | 0.868 | 0.412 | 0.412 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.872 | 0.872 | 0.430 | 0.430 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.881 | 0.881 | 0.469 | 0.469 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.875 | 0.875 | 0.443 | 0.443 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.877 | 0.877 | 0.449 | 0.449 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.880 | 0.880 | 0.462 | 0.462 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.883 | 0.883 | 0.478 | 0.478 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.871 | 0.871 | 0.423 | 0.423 |
| 37.700 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.851 | 0.851 | 0.336 | 0.336 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.866 | 0.866 | 0.403 | 0.403 |
| 41.200 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.833 | 0.833 | 0.254 | 0.254 |
| 43.300 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.826 | 0.826 | 0.225 | 0.225 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.847 | 0.847 | 0.319 | 0.319 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.849 | 0.849 | 0.325 | 0.325 |
| 47.700 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.836 | 0.836 | 0.266 | 0.266 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.853 | 0.853 | 0.344 | 0.344 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.859 | 0.859 | 0.369 | 0.369 |
| 53.500 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.824 | 0.824 | 0.213 | 0.213 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.834 | 0.834 | 0.258 | 0.258 |
| 56.200 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.792 | 0.792 | 0.069 | 0.069 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.842 | 0.842 | 0.296 | 0.296 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.886 | 0.886 | 0.491 | 0.491 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.916 | 0.916 | 0.625 | 0.625 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.962 | 0.962 | 0.831 | 0.831 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.964 | 0.964 | 0.839 | 0.839 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.915 | 0.915 | 0.620 | 0.620 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.878 | 0.457 | 0.457 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.867 | 0.867 | 0.406 | 0.406 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.853 | 0.853 | 0.346 | 0.346 |
| 74.600 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.816 | 0.816 | 0.178 | 0.178 |
| 76.200 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.768 | 0.768 | 0.0 | 0.0 |
| 78.000 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.800 | 0.800 | 0.109 | 0.109 |
| 79.500 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.817 | 0.817 | 0.185 | 0.185 |
| 81.600 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.810 | 0.810 | 0.152 | 0.152 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.878 | 0.457 | 0.457 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.906 | 0.906 | 0.579 | 0.579 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.942 | 0.942 | 0.741 | 0.741 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.988 | 0.988 | 0.947 | 0.947 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.995 | 0.995 | 0.979 | 0.979 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table F.3 (continued)

| GAPXL[a] | VALUE OF K IS: 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|---|
| -47.676 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 0.000 | 1.010 | 1.010 | 1.010 | 1.010 | 1.010 | 1.002 | 1.002 | 1.002 | 1.002 | 1.002 |
| 1.800 | 0.826 | 0.826 | 0.826 | 0.826 | 0.826 | 0.961 | 0.963 | 0.963 | 0.963 | 0.963 |
| 3.400 | 0.642 | 0.642 | 0.642 | 0.642 | 0.642 | 0.920 | 0.923 | 0.923 | 0.923 | 0.923 |
| 5.000 | 0.654 | 0.654 | 0.654 | 0.654 | 0.654 | 0.922 | 0.926 | 0.926 | 0.926 | 0.926 |
| 6.900 | 0.732 | 0.732 | 0.732 | 0.732 | 0.732 | 0.940 | 0.943 | 0.943 | 0.943 | 0.943 |
| 8.800 | 0.880 | 0.880 | 0.880 | 0.880 | 0.880 | 0.973 | 0.974 | 0.974 | 0.974 | 0.974 |
| 11.500 | 0.875 | 0.875 | 0.875 | 0.875 | 0.875 | 0.972 | 0.973 | 0.973 | 0.973 | 0.973 |
| 13.300 | 0.709 | 0.709 | 0.709 | 0.709 | 0.709 | 0.935 | 0.938 | 0.938 | 0.938 | 0.938 |
| 15.100 | 0.606 | 0.606 | 0.606 | 0.606 | 0.606 | 0.912 | 0.916 | 0.916 | 0.916 | 0.916 |
| 16.800 | 0.508 | 0.508 | 0.508 | 0.508 | 0.508 | 0.890 | 0.895 | 0.895 | 0.895 | 0.895 |
| 18.100 | 0.459 | 0.459 | 0.459 | 0.459 | 0.459 | 0.879 | 0.884 | 0.884 | 0.884 | 0.884 |
| 19.500 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.853 | 0.860 | 0.860 | 0.860 | 0.860 |
| 21.400 | 0.415 | 0.415 | 0.415 | 0.415 | 0.415 | 0.869 | 0.875 | 0.875 | 0.875 | 0.875 |
| 23.200 | 0.412 | 0.412 | 0.412 | 0.412 | 0.412 | 0.868 | 0.874 | 0.874 | 0.874 | 0.874 |
| 25.000 | 0.430 | 0.430 | 0.430 | 0.430 | 0.430 | 0.872 | 0.878 | 0.878 | 0.878 | 0.878 |
| 26.900 | 0.469 | 0.469 | 0.469 | 0.469 | 0.469 | 0.881 | 0.886 | 0.886 | 0.886 | 0.886 |
| 28.500 | 0.443 | 0.443 | 0.443 | 0.443 | 0.443 | 0.875 | 0.881 | 0.881 | 0.881 | 0.881 |
| 30.000 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.877 | 0.882 | 0.882 | 0.882 | 0.882 |
| 32.000 | 0.462 | 0.462 | 0.462 | 0.462 | 0.462 | 0.880 | 0.885 | 0.885 | 0.885 | 0.885 |
| 34.000 | 0.478 | 0.478 | 0.478 | 0.478 | 0.478 | 0.883 | 0.889 | 0.889 | 0.889 | 0.889 |
| 35.900 | 0.423 | 0.423 | 0.423 | 0.423 | 0.423 | 0.871 | 0.877 | 0.877 | 0.877 | 0.877 |
| 37.700 | 0.336 | 0.336 | 0.336 | 0.336 | 0.336 | 0.851 | 0.858 | 0.858 | 0.858 | 0.858 |
| 39.500 | 0.403 | 0.403 | 0.403 | 0.403 | 0.403 | 0.866 | 0.872 | 0.872 | 0.872 | 0.872 |
| 41.200 | 0.254 | 0.254 | 0.254 | 0.254 | 0.254 | 0.833 | 0.841 | 0.841 | 0.841 | 0.841 |
| 43.300 | 0.225 | 0.225 | 0.225 | 0.225 | 0.225 | 0.826 | 0.834 | 0.834 | 0.834 | 0.834 |
| 44.700 | 0.319 | 0.319 | 0.319 | 0.319 | 0.319 | 0.847 | 0.854 | 0.854 | 0.854 | 0.854 |
| 46.200 | 0.325 | 0.325 | 0.325 | 0.325 | 0.325 | 0.849 | 0.856 | 0.856 | 0.856 | 0.856 |
| 47.700 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.836 | 0.843 | 0.843 | 0.843 | 0.843 |
| 49.700 | 0.344 | 0.344 | 0.344 | 0.344 | 0.344 | 0.853 | 0.860 | 0.860 | 0.860 | 0.860 |
| 51.600 | 0.369 | 0.369 | 0.369 | 0.369 | 0.369 | 0.859 | 0.865 | 0.865 | 0.865 | 0.865 |
| 53.500 | 0.213 | 0.213 | 0.213 | 0.213 | 0.213 | 0.824 | 0.832 | 0.832 | 0.832 | 0.832 |
| 54.900 | 0.258 | 0.258 | 0.258 | 0.258 | 0.258 | 0.834 | 0.842 | 0.842 | 0.842 | 0.842 |
| 56.200 | 0.069 | 0.069 | 0.069 | 0.069 | 0.069 | 0.792 | 0.801 | 0.801 | 0.801 | 0.801 |
| 57.600 | 0.296 | 0.296 | 0.296 | 0.296 | 0.296 | 0.842 | 0.850 | 0.850 | 0.850 | 0.850 |
| 59.800 | 0.491 | 0.491 | 0.491 | 0.491 | 0.491 | 0.886 | 0.891 | 0.891 | 0.891 | 0.891 |
| 61.800 | 0.625 | 0.625 | 0.625 | 0.625 | 0.625 | 0.916 | 0.920 | 0.920 | 0.920 | 0.920 |
| 63.800 | 0.831 | 0.831 | 0.831 | 0.831 | 0.831 | 0.962 | 0.964 | 0.964 | 0.964 | 0.964 |
| 66.500 | 0.839 | 0.839 | 0.839 | 0.839 | 0.839 | 0.964 | 0.966 | 0.966 | 0.966 | 0.966 |
| 68.400 | 0.620 | 0.620 | 0.620 | 0.620 | 0.620 | 0.915 | 0.919 | 0.919 | 0.919 | 0.919 |
| 70.100 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.884 | 0.884 | 0.884 | 0.884 |
| 71.600 | 0.406 | 0.406 | 0.406 | 0.406 | 0.406 | 0.867 | 0.873 | 0.873 | 0.873 | 0.873 |
| 73.100 | 0.346 | 0.346 | 0.346 | 0.346 | 0.346 | 0.853 | 0.860 | 0.860 | 0.860 | 0.860 |
| 74.600 | 0.178 | 0.178 | 0.178 | 0.178 | 0.178 | 0.816 | 0.824 | 0.824 | 0.824 | 0.824 |
| 76.200 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.768 | 0.778 | 0.778 | 0.778 | 0.778 |
| 78.000 | 0.109 | 0.109 | 0.109 | 0.109 | 0.109 | 0.800 | 0.810 | 0.810 | 0.810 | 0.810 |
| 79.500 | 0.185 | 0.185 | 0.185 | 0.185 | 0.185 | 0.817 | 0.826 | 0.826 | 0.826 | 0.826 |
| 81.600 | 0.152 | 0.152 | 0.152 | 0.152 | 0.152 | 0.810 | 0.819 | 0.819 | 0.819 | 0.819 |
| 83.800 | 0.457 | 0.457 | 0.457 | 0.457 | 0.457 | 0.878 | 0.884 | 0.884 | 0.884 | 0.884 |
| 86.000 | 0.579 | 0.579 | 0.579 | 0.579 | 0.579 | 0.906 | 0.910 | 0.910 | 0.910 | 0.910 |
| 88.100 | 0.741 | 0.741 | 0.741 | 0.741 | 0.741 | 0.942 | 0.945 | 0.945 | 0.945 | 0.945 |
| 89.900 | 0.947 | 0.947 | 0.947 | 0.947 | 0.947 | 0.988 | 0.989 | 0.989 | 0.989 | 0.989 |
| 91.500 | 0.979 | 0.979 | 0.979 | 0.979 | 0.979 | 0.995 | 0.996 | 0.996 | 0.996 | 0.996 |
| 95.987 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

[a]GAPXL values are the centimeters from the bottom of the heated zone.

NUREG/CR-1011
ORNL/NUREG/TM-350
Dist. Category R3

## Internal Distribution

1. M. Bender
2-7. R. H. Chapman
8. J. C. Cleveland
9. W. G. Craddick
10. J. L. Crowley
11. R. F. Haynes
12. D. O. Hobson
13. M. H. Fontana
14. Milton Levenson
15 A. W. Longest
16. A. P. Malinauskas
17-24. J. F. Mincey
25. F. R. Mynatt
26. J. L. Rich
27. H. E. Trammell
28. J. D. White
29. Patent Office
30. Nuclear Safety Information Center
31-32 Central Research Library
33. Document Reference Section
34-36. Laboratory Records Department
37. Laboratory Records (RC)

## External Distribution

38. Office of Assistant Manager, Energy Research and Development, DOE, ORO
39. Director, Reactor Division, Energy Research and Development, DOE, ORO
40. M. L. Picklesimer, Division of Reactor Safety Research, Office of Nuclear Regulatory Research, NRC, Washington, DC 20555
41. J. P. Bohn, EG&G Idaho, Inc. INEL, Idaho Falls, ID 83401
42. D. L. Hagerman, EG&G Idaho, Inc. INEL, Idaho Falls, ID 83401
43. R. R. Hobbins, EG&G Idaho, Inc. INEL, Idaho Falls, ID 83401
44. J. R. Larson, EG&G Idaho, Inc. INEL, Idaho Falls, ID 83401
45. C. R. Hann, BNWL, P.O. Box 999, Richland, WA 99352
46. M. Fischer, PNS-Leitung, Gesellschaft für Kernforschung, Postfach 3640, 75 Karlsruhe, Federal Republic of Germany
47. L. E. Hochreiter, FLECHT-SEASET Program, Nuclear Technology Division, Power Systems, Westinghouse Electric Corporation, P.O. Box 355, Pittsburg, PA 15230
48. L. B. Thompson, Division of Reactor Safety Research, Office of Nuclear Regulatory Research, NRC, Washington, DC 20555
49. K. H. Sun, FLECHT-SEASET PMG Member, Nuclear Power Division, Electric Power Research Institute, P.O. Box 10412, Palo Alto, CA 94303
50-51. Technical Information Center, DOE
52-411. Given distribution as shown for NRC category R3 (10-NTIS)

☆U.S. GOVERNMENT PRINTING OFFICE: 1980-640-245/360