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TITLE : S.B.W.R. VACUUM BREAKER (V.B.) [illegible] PE
EXPERIMENTAL QUALIFICATION
GENERAL TEST PROCEDURE

JOB N°: C33650

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- .....
- .....

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....) .....

....) .....

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D.2.) .....

D.3.) .....

....) .....

....) .....

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E.1.) .....

E.2.) .....

E.3.) .....

....) .....

....) .....

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F.2.) .....

F.3.) .....

....) .....

....) .....

GENERAL ABSTRACTS

The WET WELL to DRY WELL VACUUM BREAKER (V.B.) is one of the safety related components of the GENERAL ELECTRIC nuclear power plant with increased inherent safety S.B.W.R.
Owing to its new conceptual design, V.B. safety functions must be warranted by means of an experimental qualification campaign performed on a prototype unit, as per IEEE standards n°323, 1984.
Qualification standards suggest the following sequence of tests÷operations to be performed on the prototype:

- Baseline performances identification in normal conditions
- Accelerated radiation ageing on sensitive subcomponents
- Accelerated thermal ageing of the complete unit
- Application of service mechanical vibrations on the complete unit, taking into account also seismic vibrations
- Simulation of the DESIGN BASIS ACCIDENT (D.B.A.) on the unit
- Reliability confirmation by means of iterative functional cycles on the unit
- Final detailed analysis of the sub components

This general procedure refers to the above-mentioned campaign planned for the V.B. prototype manufactured by FIAT COMPONENTI ED IMPIANTI PER L'ENERGIA E L'INDUSTRIA, CIEI DIVISION, Torino, ITALY.
The articulation of the qualification campaign implies the utilization of different test facilities, hence the collaboration of several firms, in details:

- the test hall of FIAT COMPONENTI ED IMPIANTI PER L'ENERGIA E L'INDUSTRIA, CIEI DIVISION, Torino, for V.B. flow tests
- the irradiation device of ....., ..... for radiation ageing
- the furnace of ....., ..... for thermal ageing

- the shaking table of ANSALDO RICERCHE, Genova, for mechanical vibrations application
- the steam chamber of BPD-DIFESA E SPAZIO, Colleferro (ROMA) for D.B.A. simulation.

Therefore the present document is composed by several sections relating to:

- General references (Section A), as:
  * reference technical documents
  * descriptions of the test item
  * identification of the general qualification program, also specifying operative competences
  * general organization of individual test procedures

- Detailed operative test procedures (Sections B÷F), represented by specific documents written by the individual cooperating firms on a uniform structural format.

## SECTION A: GENERAL REFERENCES AND ORGANIZATION

### A.1) REFERENCE DOCUMENTS

- G.E. Doc. N° 25A5445, Rev. 1, "Wet well to dry well vacuum breaker - Test specification".
- G.E. Doc. N° 25A5388, Rev. 1, "Vacuum breaker prototype - Purchase specification".
- G.E. Doc. N° 25A5395, Rev. 0, "Vacuum breaker instrumentation - Test specification".
- G.E. Doc. N° 25A5489, "Seismic responses of SBWR Reactor building".
- ASME 1989, Sect. III, Division 1, paragraph NE-6220.
- FCI-70-2-1991, Fluid controls institute, control valve seat leakage.
- MIL-STD-810 E, July 14, 1989.
- FIAT CIEI Drawing N° 2T137684, Rev. 1, and 2S137714, Rev. 1, "Vacuum breaker general assembly and outline".
- G.E. side letter of July 12, 93; leak rate testing suggested conditions.
- G.E. side letter of Sept.21, 93; DBA test technical detailed conditions.
- G.E. side letter of Dec.1, 93; V.B. radiation environment definition.

A.2) TEST SAMPLE DESCRIPTION

The V.B. is a low pressure opening and gravity assisted closing check valve, which vents the wet well to the dry well of the SBWR. A general sketch of the V.B. prototype is shown in Attachment A; its principal features are:

- a cylindrical body, provided with four discharge nozzles
- a vertically guided sealing disk, equipped with the primary elastomer soft seal
- a metallic hard seat, facing to the sealing disk and acting as a secondary seal.
- a double acting damping device, optionally mounted in line with the stem of the sealing disk.

Additional provisions of the V.B. shown in Attachment A are:

- a set of proximity sensors, to detect any displacement of the sealing disk.
- a ballast weight, placed on the sealing disk to adjust the operative lift pressure.
- a flanged stand-pipe, supporting the V.B. and simulating the real air flow duct of the V.B. installation arrangement in the SBWR building.
- outlet and inlet screens, acting as anti-missile devices in the SBWR plant: they are assembled on the V.B. during the flow tests of the qualification campaign to reproduce the total head loss of the nominal V.B. system.

Reference technical data for the V.B. are the following:

- materials:
  * V.B. body : 316L stainless steel
  * Sealing disk: 316L " "
  * Hard seat: 400 series stainless steel

- V.B. total weight: 1280 da N (2800 Lbs)
- operating temperature range: 277°÷444°K (40°÷340°F)
- operating pressure:
  * Max differential pressure in the closing direction (dry well to wet well): 241.3 KPa (35 psid)
  * Max differential pressure in the opening direction (wet well to dry well): 20.7 KPa (3 psid)

- process fluid: nitrogen, air, steam
- V.B. minimum expected equivalent relief/flow area: $9.67.10^{-2}$ $m^2$ (1.04 $feet^2$)
- V.B. expected opening set point: 3.45 KPa (0.5 psid) differential pressure (wet well to dry well)

- V.B. expexted operating response time:
  * opening time with 3.45 KPa (0,5 psid) differential pressure: 5 sec
  * closing time with 0 KPa (0 psid) differential pressure: 5 sec.

A.3) GENERAL QUALIFICATION PROGRAM

Table 1 shows the detailed V.B. prototype general qualification program in terms of:

- tests/activities identification
- tests/activities attribution to the individual cooperating firm
- reference to the specific paragraphs of the general test procedure.

TABLE 1 : S.B.W.R. VACUUM BREAKER PROTOTYPE

GENERAL QUALIFICATION PROGRAM

| Tests ÷ Activities | Pertaining to FIAT CIEI | ... | ... | ANSALDO | B.P.D. | See paragraph N° |
|---|---|---|---|---|---|---|
| 1) Hydrotest | * | | | | | B.5.1 |
| 2) Proximity instrumentation calibration | * | | | | | B.5.2 |
| 3) Baseline leak test (hard seat and disk seal) | * | | | | | B.5.3 |
| 4) Baseline low flow tests (lift pressure, stroke/speed adjustements, flow stability with/without damper) | * | | | | | B.5.4 |
| 5) Full flow tests (V.B. head ÷ flow curve) | * | | | | | B.5.5. |
| 6) Radiation ageing (on the disk seal) | | * | | | | C.5.1. |
| 7) Sistematic controls (leak rate) | * | | | | | B.5.6 |
| 8) Thermal ageing (complete V.B.) | | | * | | | D.5.1 |
| 9) Sistematic controls (leak rate, lift force proximity probes functional tests) | * | | | | | B.5.6 |

| Tests ÷ Activities | Pertaining to: FIAT CIEI | ... | .... | ANSALDO | B.P.D. | See paragraph N° |
|---|---|---|---|---|---|---|
| 10) Resonance search (Complete V.B.) | | | | * | | E.5 |
| 11) Fragility test (with leakage monitoring) | | | | * | | E.5 |
| 12) Seismic test (S.S.E. time histories application) | | | | * | | E.5 |
| 13) Sistematic controls (leak rate, lift force, proximity probes functional tests) | * | | | | | B.5.6 |
| 14) Design basic accident simulation (complete V.B., with leakage monitoring) | | | | | * | F.5.1 |
| 15) Sistematic controls (leak rate, lift force, proximity probes functional tests) | * | | | | | B.5.6 |
| 16) Grit ingestion test (silicon flour blow) | * | | | | | B.5.7 |
| 17) Sistematic controls (leak rate, lift force, proximity probes functional tests). | * | | | | | B.5.6 |

| Tests ÷ Activities | Pertaining to FIAT CIEI | .... | .... | Ansaldo | B.P.D. | See paragraph N° |
|---|---|---|---|---|---|---|
| 18) Reliability test (3000 strokes) | * | | | | | B.5.8 |
| 19) Sistematic controls (leak rate, proximity probes functional tests) | * | | | | | B.5.6 |
| 20) Foreign material seat sensitivity tests (leak tests with particles under the V.B. seal; for information only) | * | | | | | B.5.9 |
| 21) Final expertise | * | | | | | B.5.10 |

A.4) DOCUMENT ORGANIZATION

Operative procedures for the different kinds of tests ÷ activities of the V.B. prototype qualification program are defined in the specific documents written by the cooperating firms, attached to the present general procedure.

Each specific test procedure has the following structure:

- a general introduction on the operative background dealing with the performance of the tests.
- a description of the test facility arrangement, fitted with reference sketches.
- a description of the test instrumentation, explained by means of a flow diagram.
- a description of the data acquisition and elaboration system, helped by simplified block-diagrams.
- the identification of the test sequence, with following details explored for each test:
  * test set-up prerequisites
  * test performance operative procedures
  * test data recording requirements
  * test standard records to be utilized
  * test results acceptance criteria

- SECTION B : TESTS PERTAINING TO FIAT CIEI (TORINO)
  (See Doc. FIAT CIEI n° ED 45834, Attachm. B)

- SECTION C : TESTS PERTAINING TO .....(.....)
  (See Doc. ..... n° ....., Attachm. C)

- SECTION D : TESTS PERTAINING TO .....(.....)
  (See Doc. ..... n° ....., Attachm. D)

- SECTION E : TESTS PERTAINING TO ANSALDO RICERCHE (GENOVA)
  (See Doc. Ansaldo n° ....., Attachm. E)

- SECTION F : TESTS PERTAINING TO B.P.D.- DIFESA E SPAZIO (COLLEFERRO - ROMA)
  (See Doc. B.P.D. n° ....., Attachm. F)

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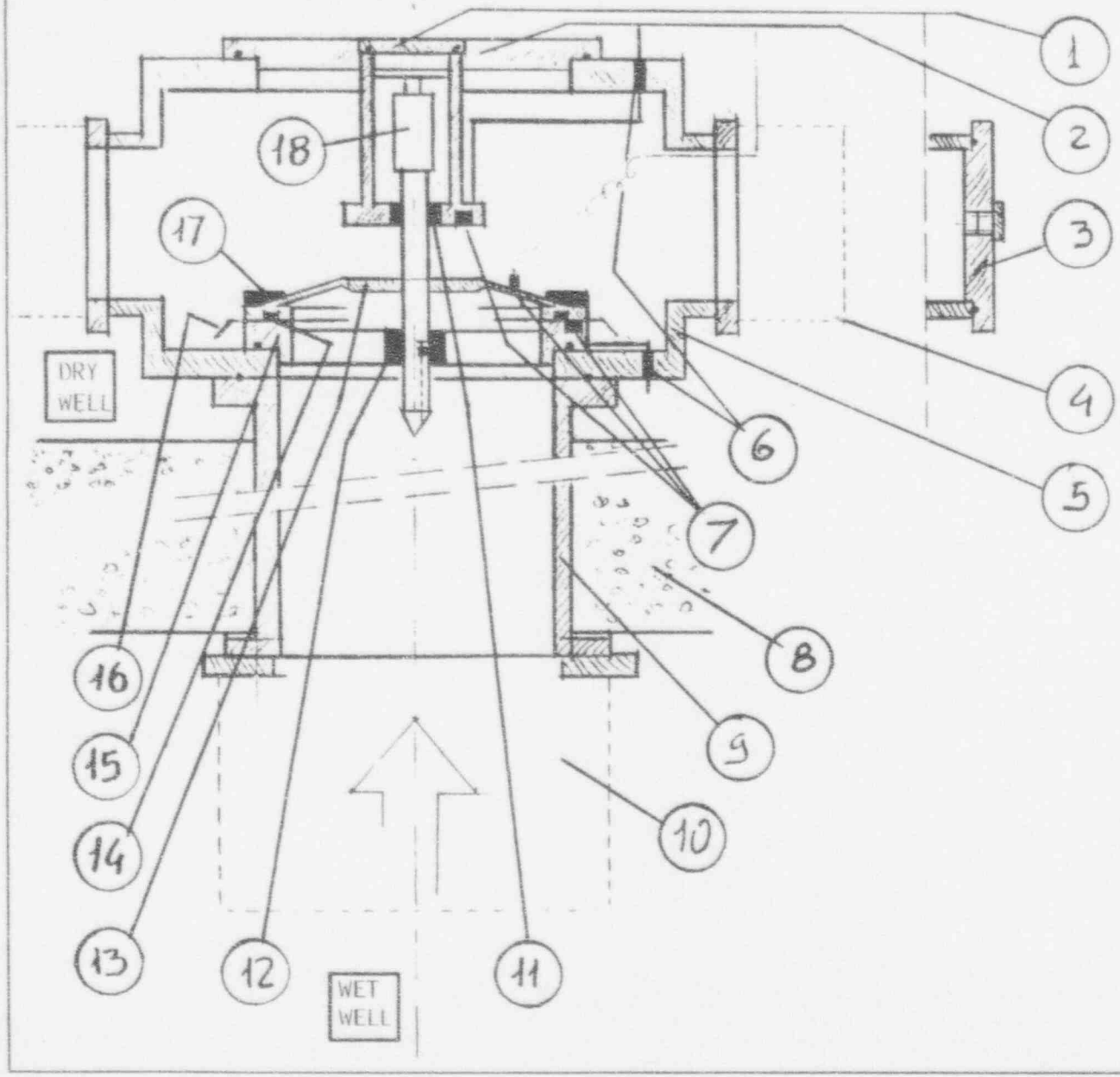


LEGENDA

1. DAMPER COVER
2. V.B. BONNET
3. LEAK TIGHT TEST FLANGE
4. OUTLET SCREEN
5. V.B. BODY (4 NOZZLES)
6. CABLE PENETRATIONS
7. PROXIMITY PROBES (5 ITEMS) AND ACCELEROMETER
8. REACTOR BUILDING FLOOR
9. V.B. SUPPORTING STAND PIPE
10. INLET SCREEN
11. DISK STEM UPPER BEARING
12. LOWER BEARING WITH ANTIROTATION DEVICE
13. V.B. SEALING DISK
14. SOFT SEAL
15. HARD SEAT
16. ANTICHATTERING DISK
17. BALLAST WEIGHT
18. DAMPER

ATTACHMENT B

FIAT CIEI DOCUMENT, N° ED 45834

FIAT CIEI TESTS PROCEDURE

Mod. CIEI 9072 Tipolitografia Baskonia - Torino

DOCUMENT TYPE: TEST PROCEDURE

INTERNAL CLASSIFICATION: N° 97/93

TITLE : S.B.W.R. VACUUM BREAKER (V.B.) PROTOTYPE
EXPERIMENTAL QUALIFICATION
FIAT CIEI TESTS PROCEDURE

JOB N°: C33650


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The present document is the Section B of the vacuum breaker prototype general test procedure, FIAT CIEI Doc. n. ED45833

| REV. | DATA | EMISSIONE | VERIFICA | APPROVAZIONE | |
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SUMMARY

B.1.) INTRODUCTION

B.2.) TEST FACILITY DESCRIPTION
- B.2.1) Flow tests stand
- B.2.2) Leak tests station

B.3.) TESTS INSTRUMENTATION
- B.3.1) Flow tests stand instrumentation
- B.3.2) Leak tests station instrumentation

B.4.) TESTS DATA ACQUISITION AND ELABORATION SYSTEMS
- B.4.1) Flow tests data acquis./elab.
- B.4.2) Leak tests data acquis./elab.

B.5.) TESTS SEQUENCE
- B.5.1) Hydrotest
- B.5.2) Proximity instrumentation calibration
- B.5.3) Baseline leak tests (hard seat and disk seal)
- B.5.4) Baseline low flow tests (lift pressure, stroke/speed adjustements, flow stability with/without damper)
- B.5.5) Full flow tests (V.B. head÷flow curve)
- B.5.6) Systematic controls (leak rate, lift force, proximity probes functional tests)
- B.5.7) Grit ingestion test (silicon flour blow)
- B.5.8) Reliability test (3000 strokes)
- B.5.9) Foreign material seat sensitivity tests (leak tests with particles under the V.B. seal)
- B.5.10) Final expertise

ATTACHMENTS:

B.1.) FIAT CIEI TEST HALL PERSPECTIVE VIEW

B.2.) V.B. FLOW TESTS FACILITY INSTALLATION PLAN VIEW

B.3.) FLOW TESTS STAND LAYOUTS

B.4.) LEAK TESTS STATION LAYOUT

B.5.) FLOW TESTS STAND INSTRUMENTATION

B.6.) LEAK TESTS STATION INSTRUMENTATION

B.7.) FLOW TESTS DATA ACQUIS./ELAB. DIAGRAM

B.8.) HYDROTEST CERTIFICATE

B.9.) PROXIMITY PROBES CALIBRATION CERTIFICATE

B.10) LEAK TEST CERTIFICATE

B.11) LOW FLOW TESTS CERTIFICATE

B.12) FULL FLOW TESTS CERTIFICATE

B.13) RELIABILITY TESTS SUMMARY CERTIFICATE

B.14) EXPERTISE CERTIFICATE

B.1.) INTRODUCTION

V.B. prototype "FLOWTEST", "Sistematic Functional Controls" and "Reliability Test" planned in its experimental qualification campaign will be run at ENEA÷FIAT CIEI test hall "A. Fogagnolo" in Torino. The test hall was built on the beginning of the eighties with the financial participation of ENEA in order to supply test devices to the italian firms involved in the late national nuclear power program.
The test hall perspective view of Attachment B.1. shows following principal facilities:

- the Primary Pumps Test Loop, for P.W.R. and B.W.R. primary R.C.P. functional testing in full nominal conditions [16 MPa (2250 psi), 563° K (552° F), 8m³/sec. (130.000 GPm), 10 MW]

- the Auxiliary Pumps Test Loop, for nuclear and conventional service pumps testing in operating conditions and in severe upset conditions (thermal shock) [2MPa (280 psi), 473°K (392°F), 0,8 m³/sec. (13.000 GPm), 10 MW]

- the Mechanisms and Valves Test Loop, for functional and endurance testing of P.W.R. control rod drive mechanism and nuclear and conventional auxiliary valves [16 MPa (2250 psi) 563°K (552° F), 8 · 10 $^{-2}$ m³/sec (1300 GPm) maximum simulated flow].

Attachment B.2. shows a plan view of the test hall where the installation of the two V.B. prototype test devices is indicated, the "flow tests stand", and the "leak tests station". Following auxiliary systems/items of the test hall are utilized during V.B. tests:
- low-voltage (380 V) power supply system
- nitrogen central supply system

- test data central acquisition and elaboration system
- instruments calibration laboratory
- the Primary Pumps Test Loop anti-noise structure, built for P.W.R. R.C.P. testing
- general lifting devices.

Assembling and disassembling operations on the V.B. prototype will be performed by CIEI specialists coming from the nuclear components assembling hall, who usually act in collaboration with test hall personnel.

B.2.) TEST FACILITY DESCRIPTION

B.2.1) Flow Tests Stand

Attachment B.3. shows different views of the stand with its over all dimensions and its principal structural features.

The general stand arrangement includes:

- A fan, supplying the air flow to the V.B. prototype, whose technical data are:
  - * Type : centrifugal, reverse blades impeller, single suction
  - * Nominal flow: 80.000 $m^3$/hr (2.84.$10^6$ $ft^3$/hr)
  - * Nominal head: 800 mm $H_2O$ (31.5 inches of water)
  - * Speed: about 1490 rpm
  - * Power: 220 KW

- A fan suction regulating valve, to totally intercept air flow during fan start-ups, and to perform a gross flow regulation during the test.

- A flexible joint, for vibration decoupling of the stand piping.

- A discharge flow modulating bypass with several purposes:
  - * to avoid unstable fan performances in the low flow region
  - * to allow continuous fan operation during V.B. repeated functional cycling (reliability tests)
  - * to increase flow regulation sensitivity
  - * to allow a precise identification of the V.B. opening differential pressure (lift pressure)

The by pass includes:

* a flow regulating shutter type valve
* a fixed flow calibration gate, set to obtain a low static pressure under the V.B. disk while the fan discharges its full flow through the by-pass, across the fully open shutter valve.

- A flow veins staightener, to increase flow measurements precision
- A pipe connection with section varying from rectangular to circular shape
- A horizontal duct made of circular thin walled pipe of 1 m (3.2 feet) diameter, 2.5 x $10^{-3}$m (0,1 inch) thickness, 15 mm (48 feet) length, required for standard flow measurements
- A bend and a vertical pipe segment of the same dimensions
- A V.B. "stand pipe" mock-up 0,6 m (24 inches) diameter, 0,660 m (26 inches) length showing
  * at the top end, a 150 LB ANSI B16.5 SCH.20 flange supporting the V.B. prototype
  * at the bottom end, a sructural flange carrying the inlet screen and bolted to the vertical pipe segment

- A V.B. supporting structure, partially made of welded beams and showing a detachable section to facilitate disassembling.
  The structure rests on the frame of the antinoise cage and on the massive pump casing utilized during the P.W.R. R.C.P. tests.
- A anti-noise structure, made of sound absorbing panels and equipped with doors, operative floors and an openable roof allowing items handling operations.

The flow stand arrangement includes also a low performances auxiliary fan installed on the primary fan casing as a possible back-up for lift pressure-low flow tests. Indicative technical data for the auxiliary fan are:

- nominal flow : 500 $m^3$/hr (17700 $ft^3$/hr)
- nominal head : 525 $mmH_2O$ (21 inches of water)

the utilization of the auxiliary fan might be required by a possible lack of sensitivity in the identification of V.B. characteristic parameters at low flows. The primary fan suction valve will be full closed and the flow modulating bypass will be plugged during auxiliary fan operation.

B.2.2) Leak Tests Station

Attachment B.4 shows this multi-purpose station, identified by means of its prevailing function. The station really acts as:

- a generic V.B. prototype support for any service operation
- a V.B. support and pressurized water supply during hydrotest
- a handy V.B. support during proximity instrumentation calibration
- a fully equipped station for V.B. systematic leak tests.

Main features of the leak tests station are:

- the V.B. supporting seat, taylored for easy assembling and disassembling of the test item
- the demineralized water supply system, equipped with a tank, a pneumatic charging pump, isolating valves and a pressure measurement section
- the nitrogen supply system, equipped with a pressure reducer, a safety valve, isolating valves and a pressure measurement section, and connected to the test hall general nitrogen supply system (racks of nitrogen bottles with a sequence of pressure reducers)
- the leak conveyer cover, to be assembled to the V.B. bottom in order to detect primary seal leaks by means of a small diameter tube submerged in water (see. ANSI/FCI 70-2-1991, note to table 2, pag. 7).

Complementary features of the leak tests station are:

- the atmospheric pressure high precision monitoring system available in the instruments calibration laboratory of the test hall

- the ambient temperature monitoring devices available for generic test hall services
- the 4 leak tight test flanges supplied with the V.B. for discharge nozzles closure during leak tests, equipped with a fast joint for water and nitrogen supply.

B.3.) TEST INSTRUMENTATION

B.3.1) Flow Tests Stand Instrumentation

A schematic instrumented flow diagram of the flow tests stand is shown in Attachment B.5.

Following instrumentation is foreseen:

- Air flow measurement and recording; techn. data:
  * Flow sensor:
    . type multiple "Pitot" tube
    . flow range: 0÷80.000 $m^3$/hr (0÷2.84.$10^6$$ft^3$/hr)
    . operative temperature: ambient
    . air speed : 29 $m/sec_{max}$ (95 feet/sec)
    . precision: 1% of instant flow, over the full flow range

  * Differential pressure transducer and square root operator:
    . power supply : 24 VDC
    . output signal: 4÷20 mA (proportional to the flow)
    . precision: ± 0.5% full scale

  * Digital indicator:
    . led type
    . 4 digits
    . power supply: 220V - 50 hz
    . precision : ± 0.25% full scale

- V.B. differential pressure measurement and recording techn. data:
  * Relative pressure transducer:
    . pressure range: 0÷1000 $mmH_2O$ (0÷40 inches of water)

. power supply: 24 VDC
. output signal: 4÷20 mA
. precision: ± 0,2% full scale

* Digital indicator:
. LED type
. 3 ½ digits
. power supply: 220V - 50 hz
. precision: ± 0.25% full scale

- V.B. disk acceleration measurement and recording; techn. data:
* Acceleration transducer:
. type: PCB 308804
. measurement range: ± 50 g
. operative temperature: ambient
. resolution: 0.003 g

- Air temperature measurement: techn. data:
* Temperature sensor:
. type: THERMORESISTANCE, PT 100
. temperat. range: 0 ÷ 200°C (32° ÷ 392°F)
. precision. ± 0.25% full scale

* Power supply:
. CONVERTER ohm/mA, 24 V DC
. output signal: 4 ÷ 20 mA
. precision: ± 0.25% full scale

* Digital indicator:
. LED type
. 3 digits
. power supply: 220 V - 50 Hz
. precision: ± 0.25% full scale.

- V B. disk displacements measurement and recording (instrumentation and electronics supplied by G.E.); techn. data:

  * Proximity sensors:
    . n° 4 "Kaman" KD1950 extreme environment probes
    . n° 1 "Kaman" KD1975 " " " "

  * Signals amplifier
    . n° 5 "Kaman" KDM-8200 electronics modules
    . output signal: 0÷2V

  * Power supply:
    n° 1 3V/42HP half-rack enclosure, 220 V - 50÷60 hz

Attachment B.5 indicates also power supply and control devices for the motors of the primary and auxiliary fans of the flow tests stand.

B.3.2) **Leak Test Station Instrumentation**

Attachment 3.6 shows a schematic diagram of the instrumentation equipping the multi-purpose leak tests station and including:

- Hydrotest pressure measurement:
  - * instrument: BOURDON pressure-gauge
  - * pressure range: 0÷1 MPa (0÷140 psi)
  - * precision: ± 1% full scale

- Leak tests pressure measurement:
  - * instrument: BOUDON pressure-gauges
  - * pressure range: 0 ÷ 160 KPa (0 ÷ 23.2 psi), and 0 ÷ 300 KPa (0 ÷ 43.5 psi)
  - * precision: ± 1% full scale

- Time measurement:
  - * instrument: JAQUET
  - * resolution: 0.2 sec

Leak tests station instrumentation complementary items are:

- Atmospheric pressure measurement:
  - * instrument: FORTIN BAROMETER
  - * precision: 1 mmHg

- Ambient temperature measurement:
  - * instrument: GIUSSANI, MOD. DP4, DIGITAL
  - * precision: ± 0.1°C (± 0.18°F).

B.4.) TESTS DATA ACQUISITION AND ELABORATION SYSTEMS

B.4.1) Flow Test Data Acquis./Elab.

The complete flow tests data travel is simplified in Attachment B.7.

The indicated stations have following functions:

- FLOW TESTS STAND : esperimental data production

- ANALOGIC AND DIGITAL TRANSDUCERS : data monitoring and transmission

- DATA ACQUISITION SYSTEM (D.A.S.) :
  . data reception
  . data engineering identif.
  . data arrangement
  . data packaging

- DATA ELABORATION SYSTEM (D.E.S.) ("DIGITAL" PDP11-34 double unit elaborator) :
  . dialogue with D.A.S.
  . data mathematical elaboration
  . data recording ("DIGITAL" standard disks)
  . data supply organization

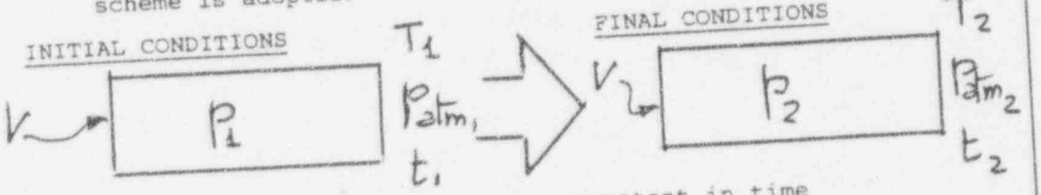
- DATA SUPPLY SYSTEM :
  . dialogue with D.E.S.
  . data final presentation:
  # monitors
  # printers
  # plotter
  # p.c. floppy disks (34" ½)

B.4.2) Leak Tests Data Acquis./Elab.

During V.B. primary/secondary seals leak tests no automatic data recording/elaboration is foreseen. All tests data will be visually acquired and manually recorded on certification standard modules. Following general philosophy applies to the planned leak tests:

- 1^st step: Attempt to perform the leak test by means of a "bubbles count" (as per ANSI/PCI 70-2-1991, note to Tab. 2, with possible different levels of seal pressurization) including:
  * test equipment set up
  * V.B. seal differential pressurization
  * leak stabilization wait
  * direct bubbles count during a measured time (bubbles/min)
  * transformation of the bubbles count rate into a standard leak rate (stcc/sec)

- 2^nd step: Leak test performance by means of a "pressure loss" measurement, if bubbles count results are not reliable (too high bubbles production rate); following operative scheme is adopted:




Where:

V = controlled pressurized volume (cc), constant in time
t1 = initial test time (sec)
p1 = initial relative pressure in volume V (Pa)
T1 = initial ambient temperature (°K)
Patm1 = initial atmospheric pressure (Pa)
t2 = final test time (sec)

P2 = final relative pressure in Volume V (Pa)

T2 = final ambient temperature (°K)

$Patm_2$ = final atmospheric pressure (Pa)

Being moreover by convention:

$Patm_o$ = "standard" atmospheric pressure (Pa)

T0 = "standard" ambient temperature (°K)

a "mean leak rate" Qm in the time interval t1 ÷ t2, expressed in (st.cc/sec), is given by:

$$Qm = \frac{V}{(t2-t1)\ Patm_o} \times \left[ (P1+Patm_1) \frac{To}{T1} - (P2+ Patm_2) \frac{T0}{T2} \right]$$

The overmentioned mean value of the leak rate is finally put in correlation with the mean value of the pressurization of volume V, pm = ½ (p1+ p2).

B.5.) TESTS SEQUENCE

B.5.1) Hydrotest

B.5.1.1.) Pre-requisites

a) V.B. nominal primary seal replaced by a conventional commercial seal, envisaged as a test tool only for hydrotest performance

b) Proximity probes absent, cable penetrations replaced by plugs.

c) Leak tight test flanges assembled on the V.B. discharge nozzles.

d) V.B. prototype placed on the supporting seat of the leak tests station and connected to the demineralized water feed line.

e) Demineralized water tanks filled with water at room temperature. Water chemistry certificate available.

f) All isolation valves closed.

B.5.1.2.) Operative procedure

a) Open filling valves and fill the V.B. prototype venting by the plug of the cable penetration on the bonnet, and by the damper cover. Close vents.

b) Isolate the filling line, open the water feed valve and start up the charging pump with V.B. internal pressure control.

c) Stop V.B. pressurization at p = 472 KPa (67.5 psi).
Shut down the charging pump and close feed water valve.
Maintain this pressurization a minimum of 10 minutes: if necessary restore pressure with the charging pump.

d) Open feed water valve and reduce V.B. internal pressure to 357 KPa (51 psi) by means of the discharge valve. Close feed water valve.
Maintain this pressure during examination for leakage of the V.B. structure. If necessary restore pressure with the charging pump.

N.B. Direct away from the surface of the V.B. any leakage from temporary seals utilized for the test, to avoid masking leaks from other joints.

e) Open feed water valve and depressurize the V.B. by means of the discharge valve. Open the venting plug on the bonnet and unscrew the damper cover. Open the drain valve and one of the bottom cable penetration plugs and empty the V.B. Close all isolation valves and disconnent the V.B. from the water supply system.

B.5.1.3.) Data recording

a) During the top pressurization phase record
- top pressure
- pressurization time

b) During the leakage examination phase record
- reduced pressure
- pressurization time
- any leakage from welded joints, connections, regions of high stress, thickness transition sections.

B.5.1.4.) Standard records

Test data will be recorded on standard module shown in Attachment B.8.

B.5.1.5.) Acceptance criteria

No leakage is acceptable from welded joints and structural parts of the V.B. prototype body.

Leakage of temporary seals, installed for the purpose of hydrotest performance, may be permitted unless the leakage exceeds the capacity to maintain system test pressure for the required amount of time.

B.5.2) Proximity Instrumentation Calibration

B.5.2.1) Pre-requisites

a) Proximity probes installed on the V.B. prototype, equipped with nominal cable penetrations, and connected to their electronics modules by prototypical cable lengths.

b) V.B. prototype placed on the supporting seat of the leak tests station.

c) Test flanges and discharge screens absent (free discharge nozzles).

d) V.B. bonnet unscrewed and equipped for frequent handling.

e) V.B. disk stem equipped for frequent liftings and lowerings

f) V.B. disk nominal primary seal absent

g) Calibrated shims and feeler gauges available.

h) Probes electronics power supply available

i) Disk and seating ring mating surfaces cleanness controlled.

B.5.2.2.) Operative procedure

B.5.2.2.1) System accuracy/repeatability demonstration

a) Verify probes behaviour at varying disk÷seat distances placing sets of calibrated shims (3 shims each time at 120°) under the disk of 0.76, 1.018, 2.036, 2.54, $3.8.10^{-3}$m (30,40,80,100,150 mils) thickness and back. Gap tolerances shall be ± $2.5.10^{-6}$m (±0.1 mils): feeler gauges will be used between the

seat and disk to assure the required gap.

b) Repeat twice the verifications of point B.5.2.2.1.a)

c) Return to zero gap between the seat and disk

B.5.2.2.2) **Particle test**

a) Verify probes behaviour by inserting a feeler gauge of $1.52.10^{-3}$m (60 mils) thickness between the seat and the disk at 45° from one proximity probe. Gap tolerance shall be ± $2.5.10^{-6}$m (±0.1 mils).

b) Repeat the verification of point B.5.2.2.2.a) with a feeler gauge of $2.036.10^{-3}$m (80 mils)

c) Return to zero gap between the seat and disk.

B.5.2.3.) Data recording

B.5.2.3.1) **System accuracy/repeatability demonstration**

Record all probes readings at each step of variation of the disk÷seat gap from zero to the max foreseen in the cycles required at point B.5.2.2.1.

B.5.2.3.2) **Particle test**

Record the disk÷seat gap indications of each proximity probe following the feelers insertions required at point B.5.2.2.2.

B.5.2.4.) Standard records

Tests data will be recorded on standard module shown in Attachment B.9.

B.5.2.5.) Acceptance criteria

B.5.2.5.1) **System accuracy/repeatability demonstration**

Proximity probes readings shall match the actual gaps indicated at point B.5.2.2.1 within ± $7.5.10^{-5}$m (±3 mils)

B.5.2.5.2) **Particle test**

At least two of the proximity probes shall indicate values greater than $0.76.10^{-3}$m (30 mils) for $1.52.10^{-3}$m (60 mils) feeler insertion, required at point B.5.2.2.2., and greater than $1.018.10^{-3}$m (40 mils) for $2.036.10^{-3}$m (80 mils) feeler insertion.

GENERAL NOTE

Paragraph B.5.2. meets the requirements of ref. G.E. Spec. 25A5395 Rev. 0 and the first calibration shall be carried out at FIAT premises by G.E. technical responsable personnel with FIAT CIEI assistance and training.

B.5.3) Baseline Leak Tests (Hard seat and disk seal)

B.5.3.1) Hard seat leak test

B.5.3.1.1) Pre-requisites

a) Proximity instrumentation nominally installed on the V.B. prototype.

b) V.B. disk nominal primary seal absent, disk directly in contact with the hard seat.

c) Leak tight test flanges assembled on the discharge nozzles

d) V.B. placed on the supporting seat of the leak tests station, connected to the nitrogen supply line.

e) Test hall general nitrogen supply system available.

f) All nitrogen isolation valves closed.

B.5.3.1.2) Operative procedure

a) Open nitrogen feed valves and pressurize the V.B. body up to 100 KPa (14 psi) acting on the pressure reducer. Reach a stable pressurization condition.

b) Close nitrogen feed valve and follow the depressurization of the V.B. body by a timer pointing out 90,80,70,60,50 KPa (12.6,11.2, 9.8,8.4, 7 psi) steps.

c) Repeat twice the overmentioned pressurization and controlled depressurization sequence.

d) Let the V.B. body depressurize completely.

e) Disconnect the V.B. from the nitrogen supply system, depressurize the nitrogen feed line and close all isolating valves.

B.5.3.1.3) Data recording

Record during each test sequence:

a) The initial stable pressurization of the V.B.

b) Initial ambient temperature and atmospheric pressure

c) Time at the five depressurization steps.

d) Final ambient temperature and atmospheric pressure.

B.5.3.1.4) Standard records

Test data will be recorded on standard module shown in Attachment B 10-1.
The module structure foresees for each test sequence:

- mean leak rate calculation at each depressurization step
- correlation of the mean leak rate to the mean value of V.B. body pressurization at each step.
- hard seat leak mean equivalent area ($A/\sqrt{K}$) calculation at each depressurization step.

- resulting hard seat leak mean equivalent area calculation (averaged over the five depressurization steps).

A final hard seat leak mean equivalent area is obtainable averaging over the three test sequences.

B.5.3.1.5) Acceptance criteria

The final hard seat leak mean equivalent area ($A/\sqrt{K}$), averaged over the required test sequences, must be less than $2.10^{-5} m^2$ ($2.16 \times 10^{-4}$ $ft^2$).

B.5.3.2) **Disk seal base line leak test**

B.5.3.2.1) Pre-requisites

a) Proximity instrumentation nominally installed on the V.B. prototype.

b) V.B. disk nominal primary seal installed

c) Leak tight test flanges assembled on the discharge nozzles.

d) Seal leak conveyer cover installed, with bubble monitoring tube placed in a transparent water container.

e) V.B. placed on the supporting seat of the leak tests station, connected to the nitrogen supply line.

f) Test hall general nitrogen supply system available.

g) All nitrogen isolation valves closed.

B.5.3.2.2) Operative procedure

a) Open nitrogen feed valves and pressurize V.B. body up to 245 KPa (35 psi) acting on the pressure reducer.

b) Close the nitrogen feed valve and wait for stabilization of possible leak from the primary seal, conveyed by the collecting cover to the water container (pressure under the collecting cover must grow over the water head of the

monitoring tube immersion, to give rise to bubbles).
Expected stabilization time with maximum acceptable seal leak = 20 min.

c) Count bubbles rising from the monitoring tube during a minimum period of 50 min.

d) Open nitrogen feed valve and depressurize V.B. body. Close nitrogen feed valves.

e) Repeat twice operations from a) to d).

f) Depressurize nitrogen feed line and close all isolation valves.

B.5.3.2.3) Data recording

Record for each test sequence:

a) V.B. body pressurization level

b) leak stabilization wait time

c) bubbles counting period

d) N° of bubbles counted

B.5.3.2.4) Standard records

Tests data will be recorded on standard module shown in Attachment B.10-2.
The module indicates also the transformation of the "bubble count rate" into a standard "leak rate" in accord with ANSI/FCI 70-2-1991, note to TAB. 2 (1 bubble = 0.15 cc).

B.5.3.2.5) Acceptance criteria

V.B. leakage across the disk seal must be less than $10^{-4}$cc/sec = 1 bubble / 25 min.

B.5.4) Baseline Low Flow Tests (Lift pressure, stroke/speed adjustements, flow stability with/without damper)

B.5.4.1) Tests without anti chattering disk and without damper

B.5.4.1.1) Pre-requisites

a) V.B.prototype nominally assembled with the exception of the antichattering device on the sealing disk, of the damper on the disk stem, and of the damper cover

b) proximity instrumentation nominally installed on the V.B. and connected to power supply and amplification electronics

c) accelerometer placed on the sealing disk (vertical direction) and connected to its power supply and apmlification system

d) V.B. prototype installed on the supporting structure of the flow tests stand

e) main V.B. feeding fan in line on the flow tests stand

f) V.B. prototype and flow tests stand instrumentation connected to data acquisition and elaboration systems

g) main fan suction regulating valve closed

h) by-pass flow regulating valve fully open

i) auxiliary V.B. feeding fan available with its relative tools.

j) 200 daN (450 lb) dynamometer available. (better than 5% precision)

k) main and auxiliary fans power supply available.

B.5.4.1.2) Operative procedure

a) Lift three times the V.B. sealing disk by means of service lifting devices, to identify a "baseline lift force" on the dynamometer. Install the damper cover on the V.B. bonnet.

b) Start-up the main fan and, slowly, partially open the suction regulating valve: the fan flow is totally diverted to the by-pass, and the pressure under the V.B. sealing disk is lower than the expected lift pressure, owing to a previous adequate calibration of the by-pass flow calibration gate. Control instrumentation readings and recordings.

c) Slowly close the by-pass flow regulating shutter valve, in order to increase the pressure under the V.B. sealing disk, until the disk lift pressure is reached and disk displacements are noticed. Go on closing the by-pass shutter valve until the V.B. is completely open, then slowly re-open the shutter

valve, in order to reduce the V.B. feed pressure, until the sealing disk leans on the seat. Finally fully re-open the by-pass shutter valve.

d) Repeat four times operations of point C.

e) Shut down the main fan and close its suction regulating valve.
Stop recording.

NOTE:

In case of lack of adequate sensitivity in the identification of V.B. characteristic parameters at low flows (disk lift pressure, V.B. opening time, V.B. closing pressure, V.B. closing time), install the auxiliary fan, plug the flow diverter by-pass, close the main fan suction regulating valve and perform above-mentioned test points. Make use of the auxiliary fan suction regulating valve to modify pressure under the V.B. sealing disk and flow across the V.B. during opening/closing phases.

B.5.4.1.3) Data recording

Following data must be recorded during the test:

a) V.B. sealing disk assembly "baseline" lift force

b) time history of the differential pressure across the disk: particular attention must be paid to the identification of the disk "lift pressure" and of the V.B. closing pressure. Adjustements may be made by ballast weight calibrations.

c) time histories of the disk displacements indicated by the 5 proximity probes: particularly important is the behaviour of the signals in the "opening start" and "closing end" periods. Instability phenomena ought to be detected by means of signals oscillations.

d) time history of the vertical acceleration of the disk, in order to confirm and possibly amplify detection capabilities of above - mentioned instability phenomena.

e) time history of the air flow behaviour during V.B. opening and closing phases.

i) V.B. opening and closing strokes time lenghts, derived from proximity probes signals time histories

g) annotations coming from visual inspections of the disk behaviour: one or more outlet screens may be disassembled from the V.B. if considerable instabilities are detected on proximity probes signals time histories

h) reference air temperature and atmospheric pressure during the test.

B.5.4.1.4) Standard records

Lift force test data will be recorded on or attached to standard module shown in Attachment B.11-1.

Low flow tests data will be recorded on or attached to standard module shown in Attachment B.11-2.

B.5.4.1.5) Acceptance criteria

Test results are evaluated by means of following criteria:

a) V.B. sealing disk "lift pressure " shall be 3.45 KPa (0,5 psid) ± 5%

b) V.B. opening and closing times shall be 5 sec or less

c) under low flow conditions the valve disk shall not chatter

NOTE:

- If point b) and c) criteria are not fulfilled tests of paragraph B.5.4.2 must necessarily be performed
- If point b) and c) criteria are fulfilled G.E. and FIAT CIEI might agree either to stop V.B. LOW FLOW TESTS at paragraph B.5.4.1, or to go on to paragraph B.5.4.2 tests to explore V.B. performances implementation capabilities.

B.5.4.2) **Tests with anti chattering disk and without damper**

B.5.4.2.1) Pre-requisites

As per B.5.4.1.1 with the exception of the antichattering device nominally assembled on the V.B. sealing disk.

B.5.4.2.2) Operative procedure

As per B.5.4.1.2.

B.5.4.2.3) Data recording

As per B.5.4.1.3. V.B. sealing disk "lift pressure" may be adjusted by ballast weight calibration. The disk behaviour in the "opening start" and "closing end" periods may be corrected by means of antichattering disk calibrations.

B.5.4.2.4) Standard records

As per B.5.4.1.4

B.5.4.2.5) Acceptance criteria

As per B.5.4.1.5.

NOTE: - If points b) and c) criteria are not fulfilled tests of paragraph B.5.4.3 must necessarily be performed.

- If point b) and c) criteria are fulfilled G.E. and FIAT CIE might agree either to stop V.B. LOW FLOW TESTS at paragraph B.5.4.2, or to go on to paragraph B.5.4.3 tests to explore V.B. performances implementation capabilities.

B.5.4.3) **Tests with anti chattering disk and with damper**

B.5.4.3.1) Pre-requisites

As per B.5.4.1.1 with the exception of the antichattering device and the damper nominally assembled on the V.B. sealing disk.

B.5.4.3.2) Operative procedure

As per B.4.5.1.2.

B.5.4.3.3) Data recording

As per B.5.4.1.3. V.B. sealing disk "lift pressure" may be adjusted by ballast weight calibration. The disk behaviour in the "opening start" and "closing end" periods may be corrected by means of antichattering disk calibrations. V.B. opening and closing times may be modified acting parametrically on the damping coefficient trigger.

B.5.4.3.4) Standard records

As per B.5.4.1.4

B.5.4.3.5) Acceptance criteria

As per B.5.4.1.5.

B.5.5) **Full Flow Tests** (V.B. head÷flow curve)

B.5.5.1) Pre-requisites

a) V.B. prototype assembled in the configuration identified by the results of paragraph B.5.4 tests (Low Flow tests).

b) Proximity instrumentation nominally installed on the V.B. and connected to power supply and amplification electronics.

c) Accelerometer placed on the sealing disk (vertical direction) and connected to its power supply and amplification system.

d) V.B. prototype installed on the supporting structure of the flow test stand.

e) Main V.B. feeding fan in line on the flow tests stand.

f) V.B. prototype and flow tests stand instrumentation connected to data acquisition and elaboration systems.

g) Main fan suction regulating valve closed.

h) By-pass flow regulating valve fully open.

i) Main fan power supply available.

B.5.5.2) Operative procedure

a) Start-up the main fan and, slowly, partially open the suction regulating valve: the fan flow is totally diverted to the by pass, and the pressure under the V.B. sealing disk is lower than the expected lift pressure, owing to a previous adequate calibration of the by-pass flow calibration gate. Control instrumentation readings and recordings.

b) Slowly close the by-pass flow regulating shutter valve, in order to increase the pressure under the V.B. sealing disk, until the disk lift pressure is reached and disk displacements are noticed. Go on closing the by-pass shutter valve until the V.B. is completely open, and then go on closing the shutter valve to increase flow across the V.B.

c) Stabilize flow with increasing differential pressure at 400, 450, 500, 550, 600, 650, 700 mm $H_2O$ steps (0.57, 0.64, 0.71, 0.79, 0.86, 0.93, 1 psid): when necessary (by-pass shutter valve completely closed) open the fan suction regulating valve to increase flow across the V.B.

d) Partially close fan suction regulating valve and then re-open by-pass shutter valve to decrease flow across the V.B., and stabilize flow with decreasing differential pressure at same steps as point c).

e) Repeat twice operations of points c) and d)

f) Slowly go on reopening the shutter valve until the V.B. closes, then fully reopen the shutter.

g) Shut down the main fan, and close its suction regulating valve. Stop recording.

B.5.5.3) Data recording

Following data must be recorded during the test:

a) Time history of the differential pressure across the V.B.

b) Time histories of the V.B. sealing disk displacements (proximity probes signals)

c) Time history of the vertical acceleration of the disk

d) Time history of the air flow across the V.B.

e) V.B. opening and closing times

f) Reference air temperature and atmospheric pressure during the test.

B.5.5.4) Standard records

Test data will be recorded on or attached to standard module shown in Attachment B.12-1.

B.5.5.5) Acceptance criteria

Flow rate across the V.B. shall exceed values provided in Attachment B.12-2 from the "lift pressure" up to at least 6.9 KPa (1 psid)

B.5.6) Systematic controls (Leak rate, lift force, proximity probes functional tests))

B.5.6.1) **Disk seal systematic leak test**

B.5.6.1.1) 1st step bubble test

B.5.6.1.1.1) Pre-requisites

a) V.B. prototype nominally assembled, with the exception of the outlet screens replaced by the leak tight test flanges on the discharge nozzles.

b) Seal leak conveyer cover installed, with bubble monitoring tube placed in a transparent water container.

c) V.B. placed on the supporting seat of the leak tests station, connected to the nitrogen supply line.

d) Test hall general nitrogen supply system available

e) All nitrogen isolation valves closed.

B.5.6.1.1.2) Operative procedure

a) Open nitrogen feed valves and pressurize V.B. body up to 20.5 KPa (3psi) acting on the pressure reducer.

b) Close the nitrogen feed valve and wait for stabilization of possible leak from the primary seal, conveyed by the collecting cover to the water container (pressure under the collecting cover must grow over the water head of the monitoring tube immersion to produce bubbles).

Suggested stabilization time: some seconds.

c) Count bubbles rising from the monitoring tube diring a minimum period of 1 minute.

NOTE

If bubbles count is unreliable (too many bubbles per second) open nitrogen feed valve, depressurize V.B. body and set-up paragraph B.5.6.1.2 test performance

d) Open nitrogen feed valve and depressurize V.B. body. Close nitrogen feed valve.

e) Repeat twice operations from a) to d)

f) Repeat operations from a) to e) at 41, 69 and 103 KPa (6,10,15 psi) of V.B. body pressurization.

g) Depressurize nitrogen feed line and close all isolation valves.

B.5.6.1.1.3) Data recording

Record for each test sequence:

a) V.B. body pressurization level

b) leak stabilization wait time

c) bubbles counting period

d) N° of bubbles counted

B.5.6.1.1.4) Standards records

Tests data will be recorded on standard module shown in Attachment B.10-2.
The module indicates also the transformation of the "bubbles count rate" into a standard "leak rate" in accord with ANSI/FCI 70-2-1991, note to Tab. 2 (1 bubble = 0,15 CC).

B.5.6.1.1.5) Acceptance criteria

Leak rate shall not exceed values provided in Attachment B.10-4 at test pressure.

NOTE: Failure of elastomers doesn't constitute V.B. failure. The time and manner of failure will be the basis for conservatively defined replacement intervals.

B.5.6.1.2) 2nd step Pressure Loss test

B.5.6.1.2.1) Pre-requisites

As per B.5.6.1.1.1 with the exception of the absence of the seal leak conveyer cover.

B.5.6.1.2.2) Operative procedure

a) open nitrogen feed valves and pressurize V.B. body up to 20.5 KPa (3 psi) acting on the pressure reducer
b) close nitrogen feed valve and wait for 10 minutes to allow V.B. internal pressure decrease

c) open nitrogen feed valve and depressurize V.B. body. Close nitrogen feed valve

d) repeat twice operations from a) to c)

e) repeat operations from a) to d) at 41, 69 and 103 KPa (6, 10, 15 psi) of V.B. body pressurization

f) depressurize nitrogen feed line and close all isolation valves.

B.5.6.1.2.3) Data recording

Record during each pressure loss test:

a) initial pressurization of the V.B. body

b) initial ambient temperature and atmospheric pressure

c) wait time for V.B. body depressurization

d) final pressurization of V.B. body

e) final ambient temperature and atmospheric pressure

B.5.6.1.2.4) Standard records

Test data will be recorded on standard module shown in Attachment B.10-3.

The module structure foresees for each pressure loss test:

- mean leak rate calculation
- correlation of the mean leak rate to the mean value of the V.B. body pressurization during the test.

Resulting mean leak rates for each V.B. pressurization level are obtained by averaging over single pressure loss tests.

B.5.6.1.2.5) Acceptance criteria

Leak rate shall not exceed values provided in Attachment B.10-4 at test pressure.

NOTE: Failure of elastomers doesn't constitute V.B. failure. The time and manner of failure will be the basis for conservatively defined replacement intervals.

B.5.6.2) Disk assembly lift force systematic controls

B.5.6.2.1) Pre-requisites

a) V.B. protocype nominally assembled, with the exception of the damper cover

b) V.B. placed on the supporting seat of the leak tests station

c) proximity instrumentation connected to power supply, amplification and recording systems

d) 200 daN (450 lb) dynanometer available (better than 5% precision)

e) probes electronics power supply available

B.5.6.2.2) Operative procedure

a) lift three times the V.B. sealing disk assembly by means of service lifting devices, controlling lift force behaviour on the dynamometer. Stop proximity probes recording.

B.5.6.2.3) Data recording

Record during the test:

a) disk assembly lift force readings

b) annotations on possible disk lifting anomalies (discontinuities, force oscillations, jerkily motion,...)

B.5.6.2.4) Standards records

Data will be recorded on standard module of Attachment B.11-1.

B.5.6.2.5) Acceptance criteria

Max acceptable force variation 5% of "baseline lift force"

B.5.6.3) Proximity probes calibration systematic controls

B.5.6.3.1) Pre-requisites

a) V.B. prototype nominally assembled, and placed on the supporting seat of the leak tests station

b) proximity probes connected to power supply, amplification and recording systems

c) V.B discharge nozzles free from flanges or screens

d) V.B. bonnet unscrewed and equipped for frequent handling

e) V.B. disk stem equipped for frequent liftings and lowerings

f) calibrated shims and feeler gauges available

g) probes electronics power supply available

B.5.6.3.2) Operative procedure

As per B.5.2.2.1

B.5.6.3.3) Data recording

As per B.5.2.3.1

B.5.6.3.4) Standard records

As per B.5.2.4

B.5.6.3.5) Acceptance criteria

As per B.5.2.5.1

B.5.7) Grit Ingestion test (Silicon flour blow)

B.5.7.1) Pre-requisites

a) V.B. prototype nominally assembled, with inside surfaces covered with a thin coat of mineral oil.

b) V.B. prototype installed on the supporting structure of the flow tests stand.

c) Proximity instrumentation connected to power supply, amplification electronics and recording system.

d) Flow, temperature and pressure transducers disassembled from the flow tests stand, and replaced by plugging devices.

e) Main V.B. feeding fan in line on the flow tests stand.

f) Main fan suction regulating valve closed.

g) By-pass flow regulating valve fully open.

h) Dust abating curtains placed around the V.B., to limit anti-noise structure contamination.

i) 0,454 Kg (1 lb) of silicon flour available.

j) Proximity probes power supply available.

k) Main fan power supply available.

B.5.7.2) Operative procedure

a) Start-up the main fan and, slowly, partially open the suction regulating valve: the fan flow is totally diverted to the by-pass, and the pressure under the V.B. sealing disk is lower than the lift pressure owing to the calibration of the by-pass gate.
Control proximity probes recordings.

b) Slowly close the by-pass flow regulating shutter valve to increase the pressure under the V.B. disk, until the lift pressure is reached and disk displacements are noticed. Go on closing the shutter valve until the V.B. is completely open. Completely close the shutter valve.

c) Slowly empty the silicon flour container in the air flow at the main fan suction, to blow it trough the V.B.. Maintain flow for at least 1 minute.

d) Re-open the by pass shutter valve to reduce flow across the V.B. and then to close it. Fully open the shutter valve.

e) Shut-down the main fan, and close its suction regulating valve. Stop recording.

B.5.7.3) Data recording

Record proximity probes signals during test operations, and possible annotations on their behaviour.

B.5.7.4) Standard records

Test data will be recorded on or attached to standard module shown in Attachment B.11-2.

B.5.7.5) Acceptance criteria

Silicon flour composition in accordance with MIL-STD-810 E (July 1989), method 510.3, section I-3.2.d (1) (b).

NOTE

Silicon flour captured by the oil film on the inside surfaces of the V.B. must not be removed before subsequent tests ("RELIABILITY TEST" and "SEAT SENSITIVITY TEST")

B.5.8) Reliability test (3000 strokes)

B.5.8.1) Pre-requisites

a) V.B. prototype nominally assembled (same configuration as per "Full Flow tests" paragraph B.5.5).

b) V.B. inside surfaces contaminated by silicon flour blown through the V.B. during "Grit Ingestion test", paragraph B.5.7.

c) Proximity instrumentation connected to power supply and amplification electronics.

d) V.B. prototype installed on the supporting structure of the flow tets stand.

e) Main V.B. reeding fan in line on the flow tests stand.

f) Flow tests stand nominally equipped with pressure, temperature and flow transducers.

g) V.B. prototype and flow tests stand instrumentation connected to data acquisition and elaboration systems.

h) Main fan suction regulating valve closed.

i) By-pass flow regulating valve fully open.

j) Main fan power supply available.

B.5.8.2) Operative procedure

a) Start-up the main fan and, slowly, partially open the suction regulating valve: the fan flow is totally diverted to the by-pass and the pressure under the V.B. disk is lower than the lift pressure owing to the by-pass calibration gate. Control instrumentation readings and recordings.

b) Slowly close the by-pass flow regulating shutter valve in order to completely open the V.B. and stabilize a differential pressure of 520 mm $H_2O$ (0.74 psid): maintain flow for at least 40 sec.

c) Slowly completely re-open the shutter valve in order to close the V.B. and divert the fan full flow to the by-pass.

d) Repeat 3000 times operations of point b) and c).

NOTE:

Presently 8÷9 hours a day of testing are planned, 3000 strokes being the integral performance to be reached. At the end of each daily phase operations of point e) will be performed.

e) Shut-down the main fan, and close its suction regulating valve. Stop recording.

B.5.8.3) Data recording

Following data must be recorded during the test:

a) Time history of the differential pressure across the V.B.

b) Time histories of the V.B. sealing disk displacements (proximity probes signals)

c) Time history of the air flow across the V.B.

d) Reference air temperature and atmospheric pressure during the test.

B.5.8.4) Standard records

Test data will be summarized on or attached to standard module shown in Attachment B.13 Sample records of V.B. "lift pressure", "opening time", "stabilized differential pressure", "stabilized flow", "closing time" are foreseen every 100 strokes.

B.5.8.5) Acceptance criteria

No failure in V.B. lift on demand over 3000 operations.

B.5.9) **Foreign Material Seat Sensitivity test** (Leak tests with particles under the V.B. seal)

B.5.9.1) Pre-requisites

a) V.B. prototype nominally assembled, with the exception of the damper cover and of the outlet screens on the discharge nozzles.

NOTE :

V.B. prototype general conditions must be those resulting from the "RELIABILITY TEST" of paragraph B.5.8.

b) V.B. placed on the supporting seat of the leak test station.

c) Rough metallic or ceramic particles (or scraps, or grains) of different average dimensions available.

d) Test hall general nitrogen supply system available

e) All nitrogen isolation valves closed.

B.5.9.2) Operative procedure

a) Place one particle of average dimensions of about $0,38 \times 10^{-3}$m (15 mils) under the soft seal of the V.B. disk. Replace and nominally close the damper cover, and assemble the leak tight test flanges.

b) Connect the V.B. to the nitrogen supply system, open nitrogen feed valves and pressurize V.B. body up to 20,5 KPa (3psi) acting on the pressure reducer.

c) Close nitrogen feed valve and wait for 10 minutes to allow V.B. internal pressure decrease.

NOTE:

If the depressurization rate is too high to allow a wait time of 10 minutes, stop the wait time when one half of initial pressurization is reached.

d) Open nitrogen feed valve and depressurize V.B. body.
Close nitrogen feed valve.

e) Repeat twice operations from b) to d).

f) Repeat operations from b) to e) at 41, 69, and 103 KPa (6,10,15 psi) of V.B. body pressurization.

g) Disconnect the V.B. from the nitrogen supply system, disassemble leak tight test flanges and damper cover.

h) Repeat operations from a) to g) with particles of 0,76 x $10^{-3}$ and 1.27 x $10^{-3}$m (30 and 50 mils) average dimensions placed under the soft seal of the V.B. disk.

i) Depressurize nitrogen feed line and close all isolation valves.

B.5.9.3) Data recording

Record during each pressure loss test:

a) Average dimensions of the particle placed under the soft seal of the V.B. disk.

b) Initial pressurization of the V.B. body.

c) Initial ambient temperature and atmospheric pressure.

d) Wait time for V.B. body depressurization.

e) Final pressurization of the V.B. body.

f) Final ambient temperature and atmospheric pressure.

B.5.9.4) Standard records

Test data will be recorded on standard module shown in Attachment B.10-3.

The module structure foresees for each pressure loss test:

- Mean leak rate calculation
- Correlation of the mean leak rate to the mean value of the V.B. body pressurization during the test.

Resulting mean leak rates for each V.B. pressurization level are obtained by averaging over single pressure loss tests.

B.5.9.5) Acceptance Criteria

Leak rates will be compared to values provided in Attachment B.10-4 at test pressure:

**Results are for G.E. information only**, out of the V.B. prototype qualification test campaign.

B.5.10) **Final Expertise**

B.5.10.1) Pre-requisites

a) All tests of the V.B. qualification campaign performed

b) V.B. prototype completely assembled in the final test conditions

c) V.B. prototype placed in the final inspection hall of the shop (including inlet screen)

d) Shop drawings, inspection÷measurement tools and camera available.

B.5.10.2) Operative procedure

a) Completely disassemble the V.B. prototype, with the exception of the proximity probes clamped cables.

NOTE:

Try not to alter items surface conditions during disassembling (e.g. grit presence, oil presence, oxidations, corrosions,...)

b) Perform visual inspection on each V.B. item, and immediately take pictures of any possible anomaly.

c) Perform dimensional and surface roughness checks as required at point B.5.10.3.

d) Individually package V.B. items with identifying devices, for planned subsequent shop operations.

B.5.10.3) Data recording

a) Take annotations (and if necessary pictures) of V.B. items surface conditions, with particular attention for:

- Disk soft seal
- Hard seat
- Disk stem
- Disk stem bearings
- Proximity pobes
- Proximity probes connectors, cables and penetrations
- Inlet and oulet screens

NOTE:

Important features are:

- Structural deformations
- Wear marks
- Local grit accumulation
- Possible oxidation traces
- Initial corrosion indications

b) Make dimensional checks (and if necessary surface roughness checks) on:

- Disk
- Disk stem
- Lower and upper bearings
- Hard seat
- Disk soft seal

B.5.10.4) Standard records

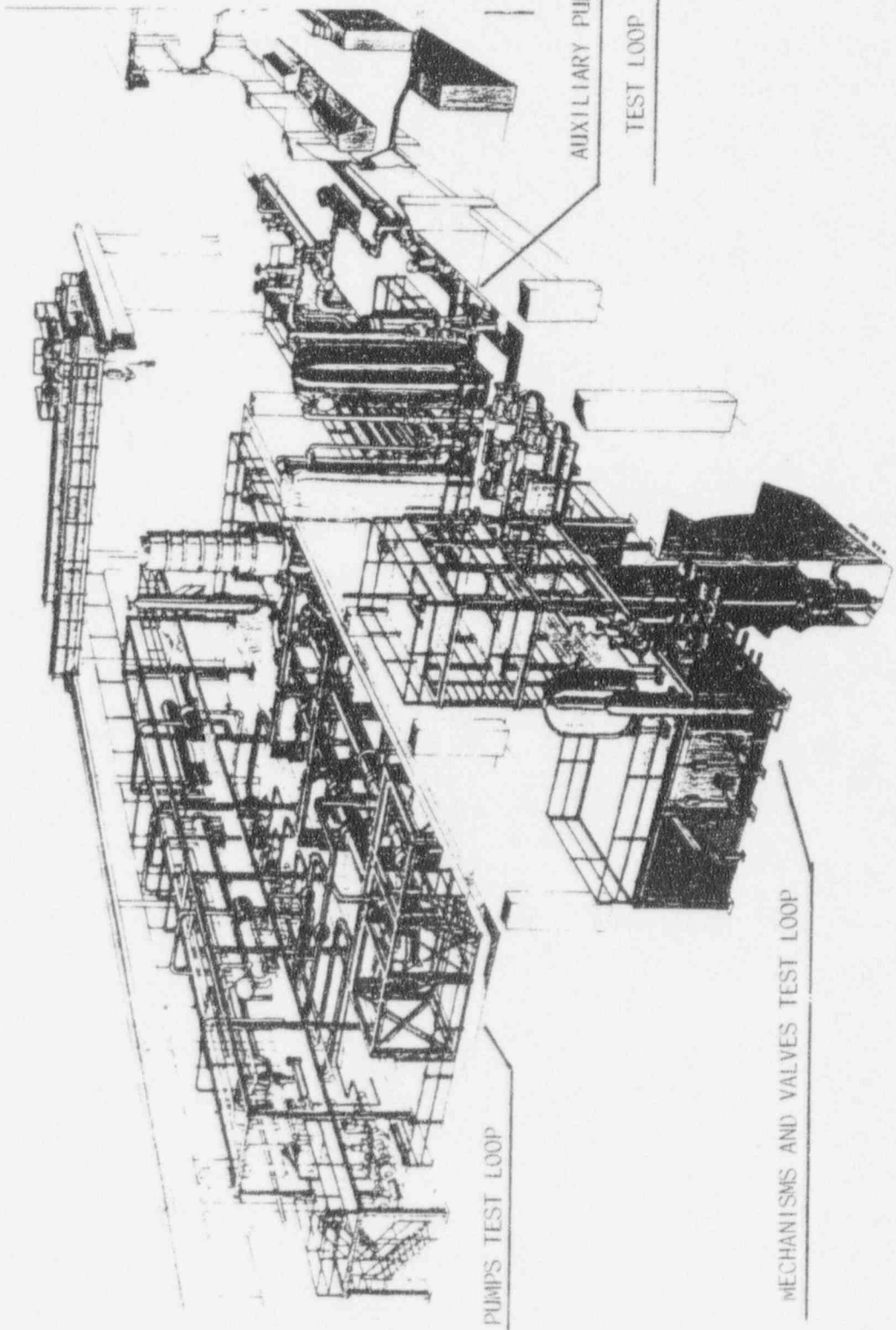
Record/attach expertise results on/to standard module shown in Attachment B.14.

B.5.10.5) Acceptance criteria

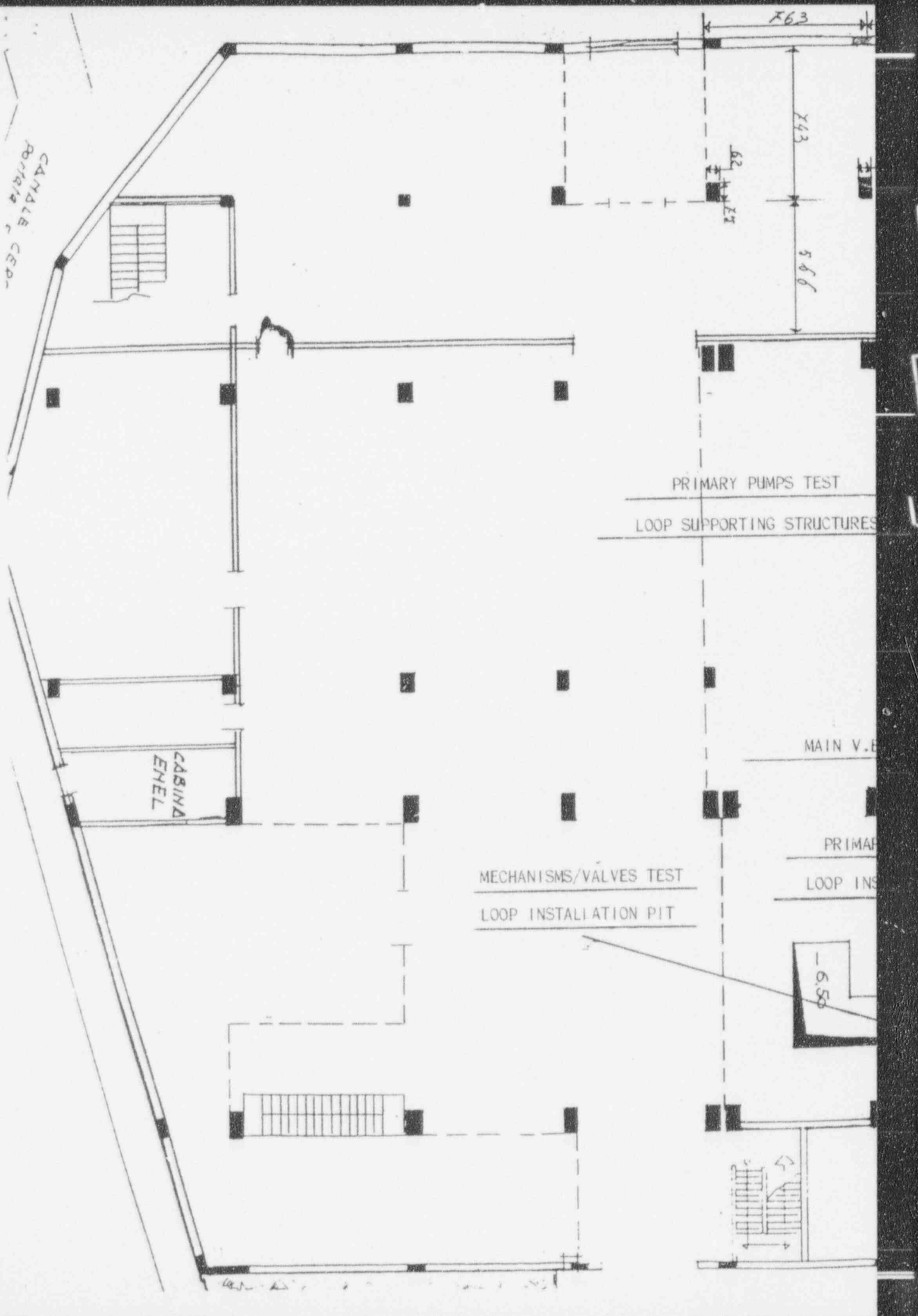
Not applicable. EXPERTISE RESULTS WILL BE PART OF THE FINAL QUALIFICATION TEST REPORT.

NOTE:

Failure of elastomers in the course of the test campaign does not constitute V.B. failure.
The time and manner of failure will be the basis for conservatively defined replacement intervals.




Mod. CIEI 9072 - Tip. GABO


PRIMARY PUMPS TEST
LOOP SUPPORTING STRUCTURES
MECHANISMS/VALVES TEST
LOOP INSTALLATION PIT
CABINA ENEL

650

ATTACHMENT B.2.

V.B. PROTOTYPE QUALIFICATION TESTS

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V.B. FLOW TESTS FACILITY INSTALLATION PLAN VIEW

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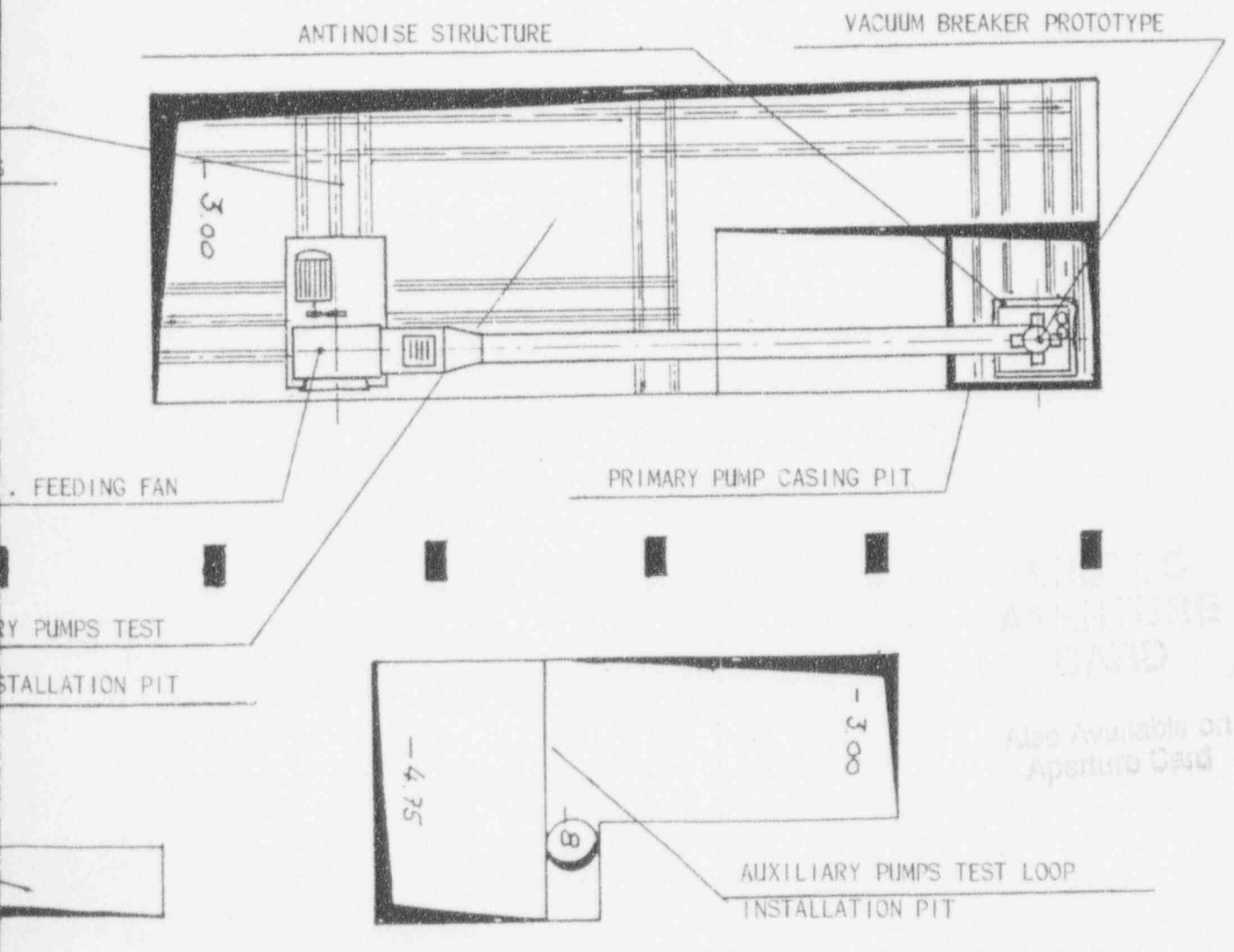


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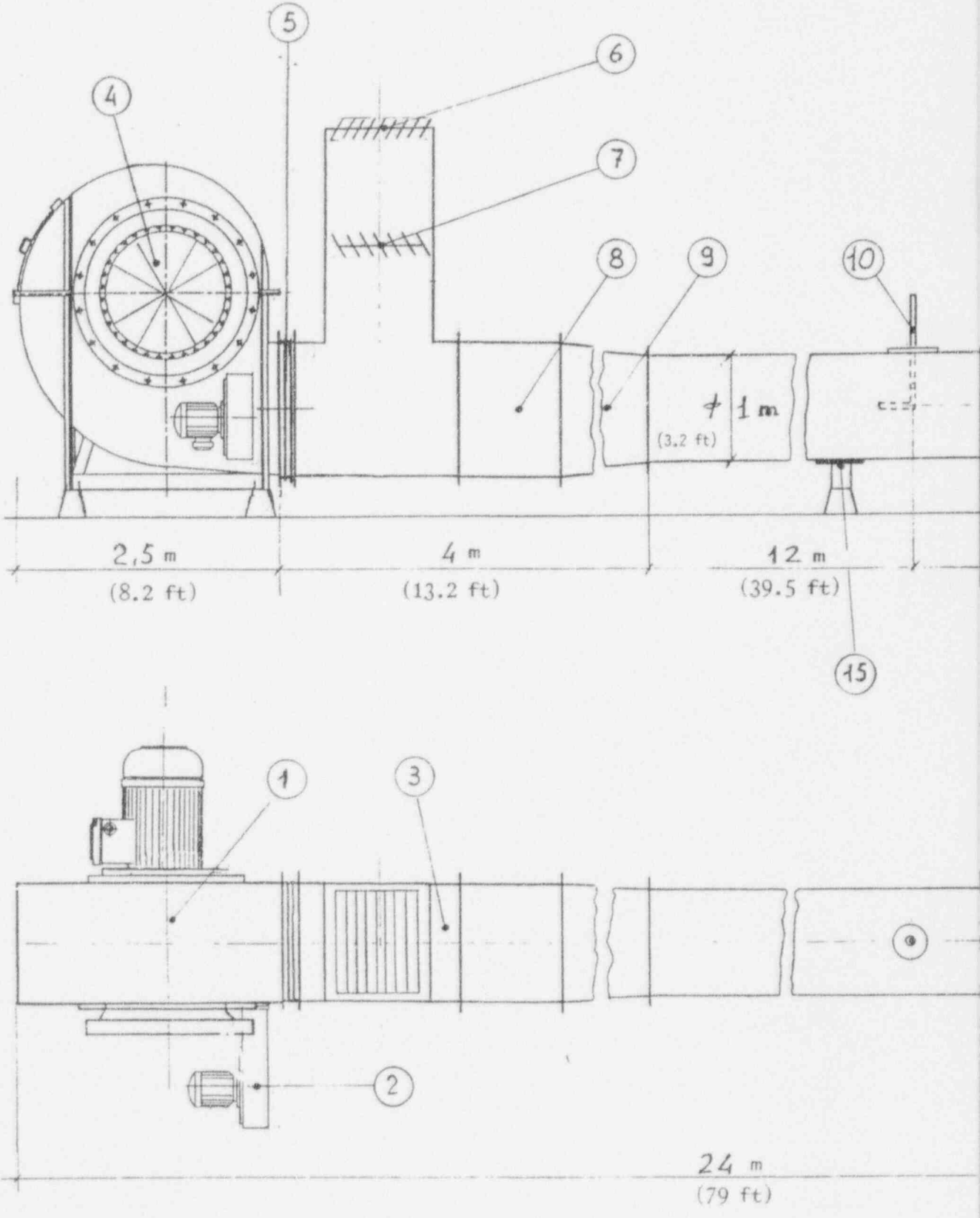
S.B.W.R. VACUUM BREAKER (V.B.) PROTOT

QUALIFICATION TESTS

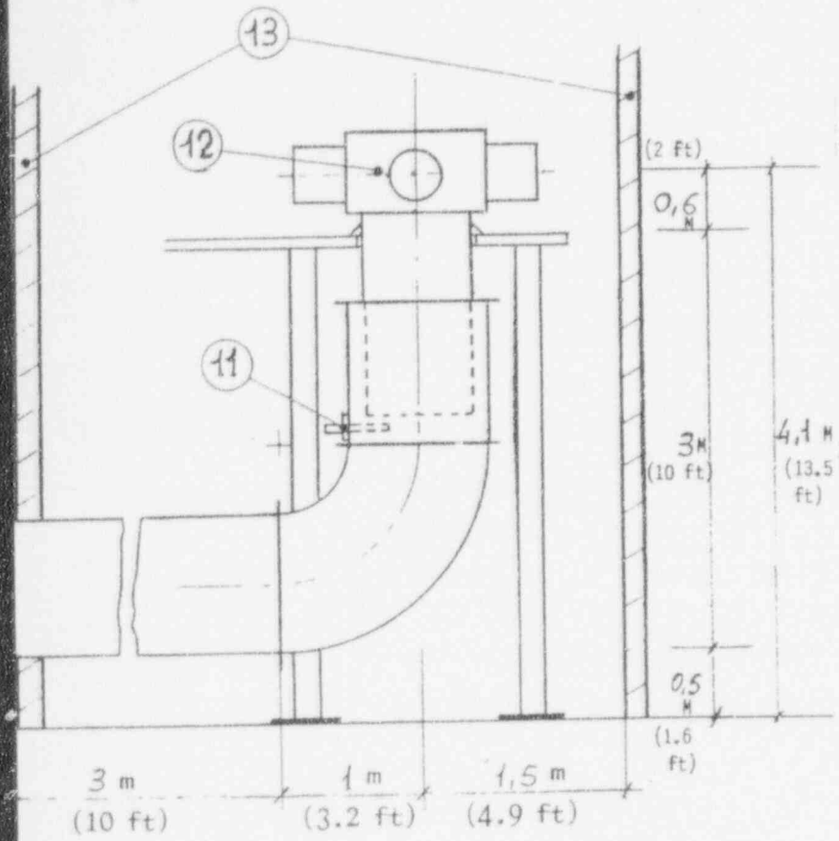
PERFORMANCE AND RELIABILITY TESTS ST

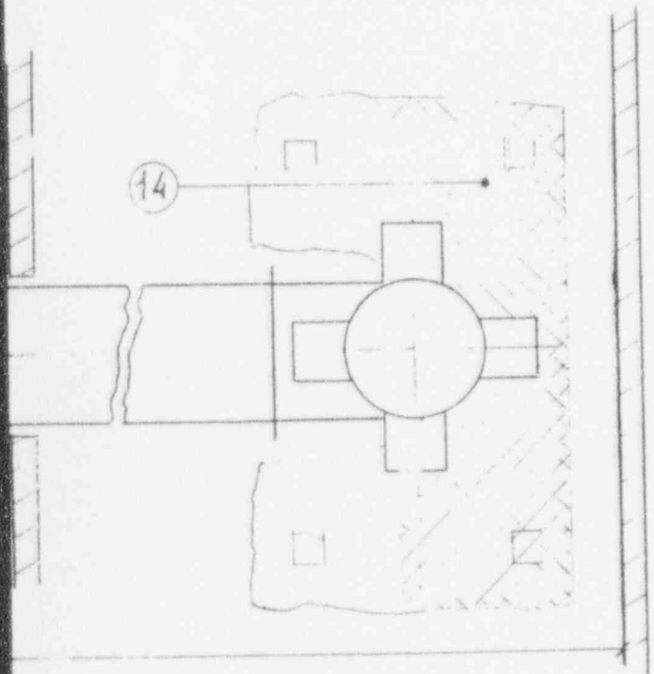
(FIAT CIEI TEST HALL)



ATTACHMENT 8.3.

SHEET 1/2








1) Main V.B. feeding fan
(Nominal performances
- Flow: 80.000 $m^3$/hr
(2.84 x $10^6$ $ft^3$/hr)
- Head: 800 mm $H_2O$
(31.5 inches of water)
- Speed: 1.490 rpm
- Power: 220 KW)

2) Auxiliary V.B. feeding fan, for "lift pressure" and "low flow" tests
(Flow: 500 $m^3$/hr (17700 $ft^3$/hr);
Head: 525 mm $H_2O$ (21 inches of water))

3) Main fan flow diverter by-pass

4) Main fan suction regulating valve

5) Antivibration joint

6) By-pass flow calibration gate

7) By-pass flow regulation valve

8) Flow veins straightener

9) Pipe connection (rectangular ÷ circular)

10) Flow meter ("PITOT" tube) (from 0 to 80.000 $m^3$/hr)

11) Pressure transducer (from 0 to 1.000 mm $H_2O$ (40 inches of water)

12) V.B. prototype

13) Anti-noise structure

14) V.B. supporting structure operative floor

15) Pipe support

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SHEET 2/2

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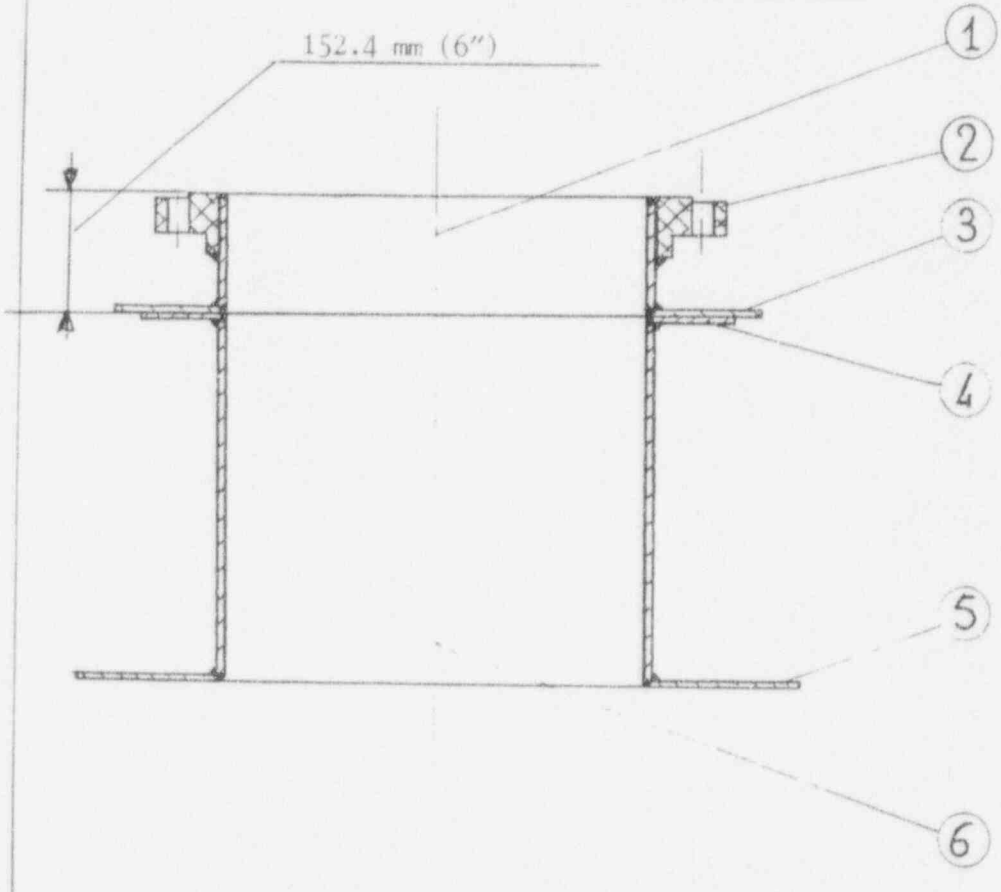
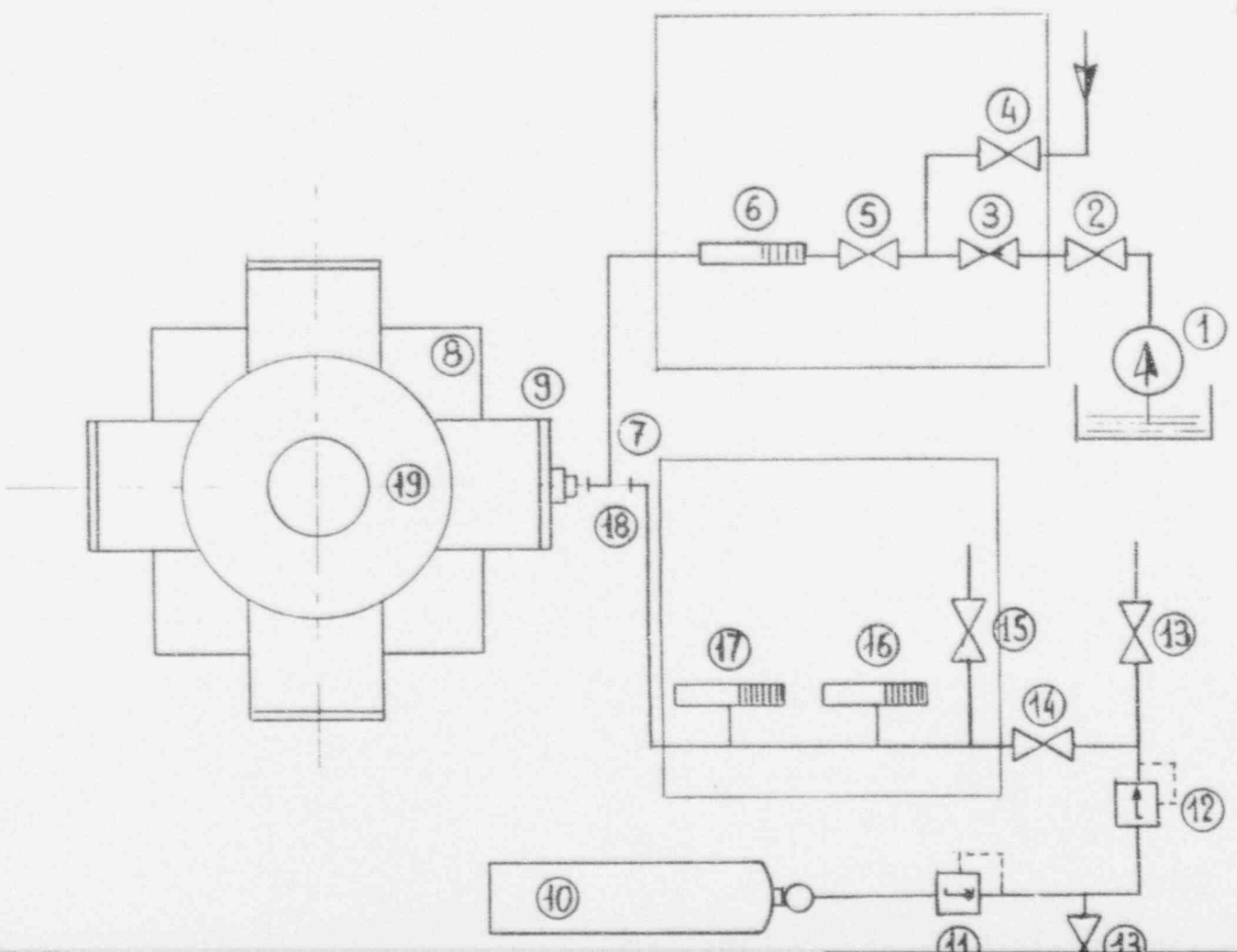
## V.B. SUPPORTING STAND PIPE




| | |
|---|---|
| 1 | UPPER DRUM 24" SCH. 20 |
| 2 | 24" ANSI - 150 SERIES FLANGE |
| 3 | INTERMEDIATE ASSEMBLING FLANGE (*) |
| 4 | FLOW TESTS STAND ASSEMBLING FLANGE |
| 5 | INLET SCREEN AND PIPING ASSEMBLING FLANGE |
| 6 | LOWER DRUM 24" SCH. 20 |
| | |

NOTE:

(*) FITTING EITHER WITH FIAT CIEI FLOW TESTS STAND, OR WITH ANSALDO RICERCHE SHAKING TABLE




LEGENDA

1. DEMINERALIZED WATER CHARGING PUMP
2. CHARGING PUMP ISOLATION VALVE
3. DISCHARGE VALVE
4. DEMINERALIZED WATER FEED VALVE
5. V.B. ISOLATION VALVE
6. HYDROTEST PRESSURE MEASUREMENT
7. WATER LINE CONNECTION
8. V.B. SUPPORTING SEAT
9. LEAK TIGHT TEST FLANGE
10. NITROGEN BOTTLE
11. PRESSURE REDUCER
12. PRESSURE REDUCER
13. DISCHARGE VALVE
14. V.B. ISOLATION VALVE
15. SAFETY VALVE

ATTACHMENT B.4.

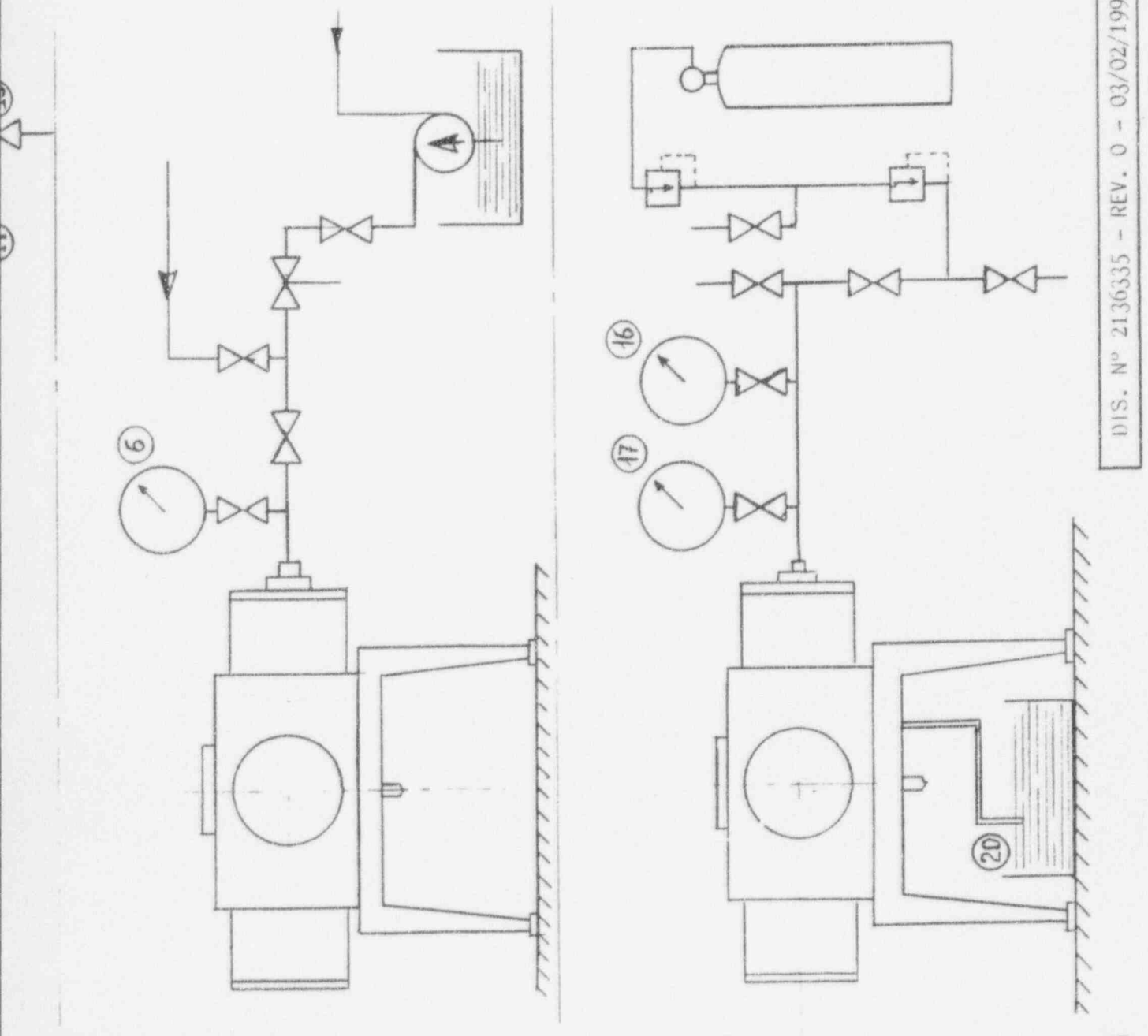
V.B. PROTOTYPE QUALIFICATION TESTS

LEAK TEST STATION LAYOUT

SHEET 1/2



16. PRESSURE MEASUREMENT (HIGH LEVEL)
17. PRESSURE MEASUREMENT (LOW LEVEL)
18. NITROGEN LINE CONNECTION
19. V.B. PROTOTYPE
20. BUBBLES COUNTING DEVICE

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BUBBLES COUNTING DEVICE

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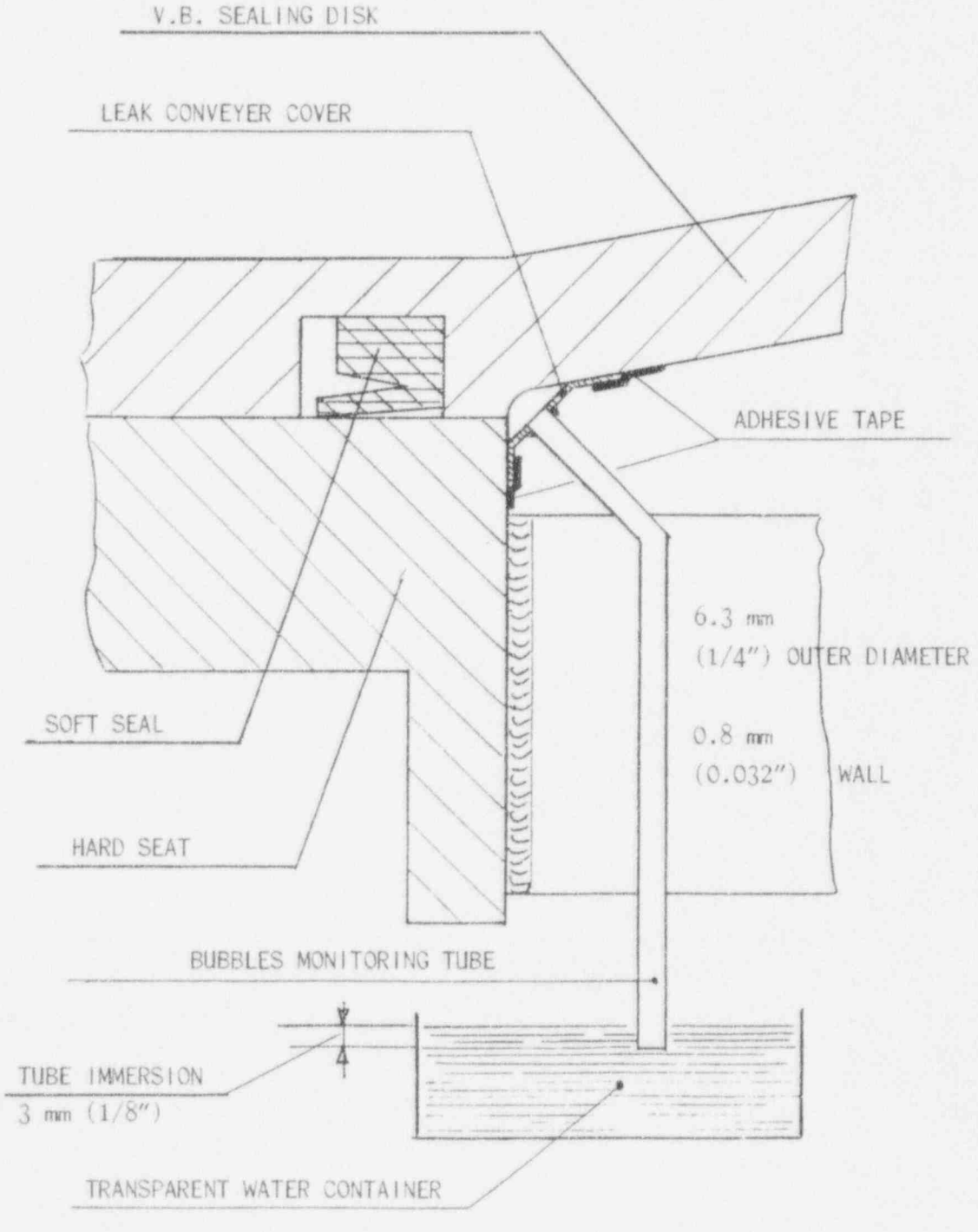
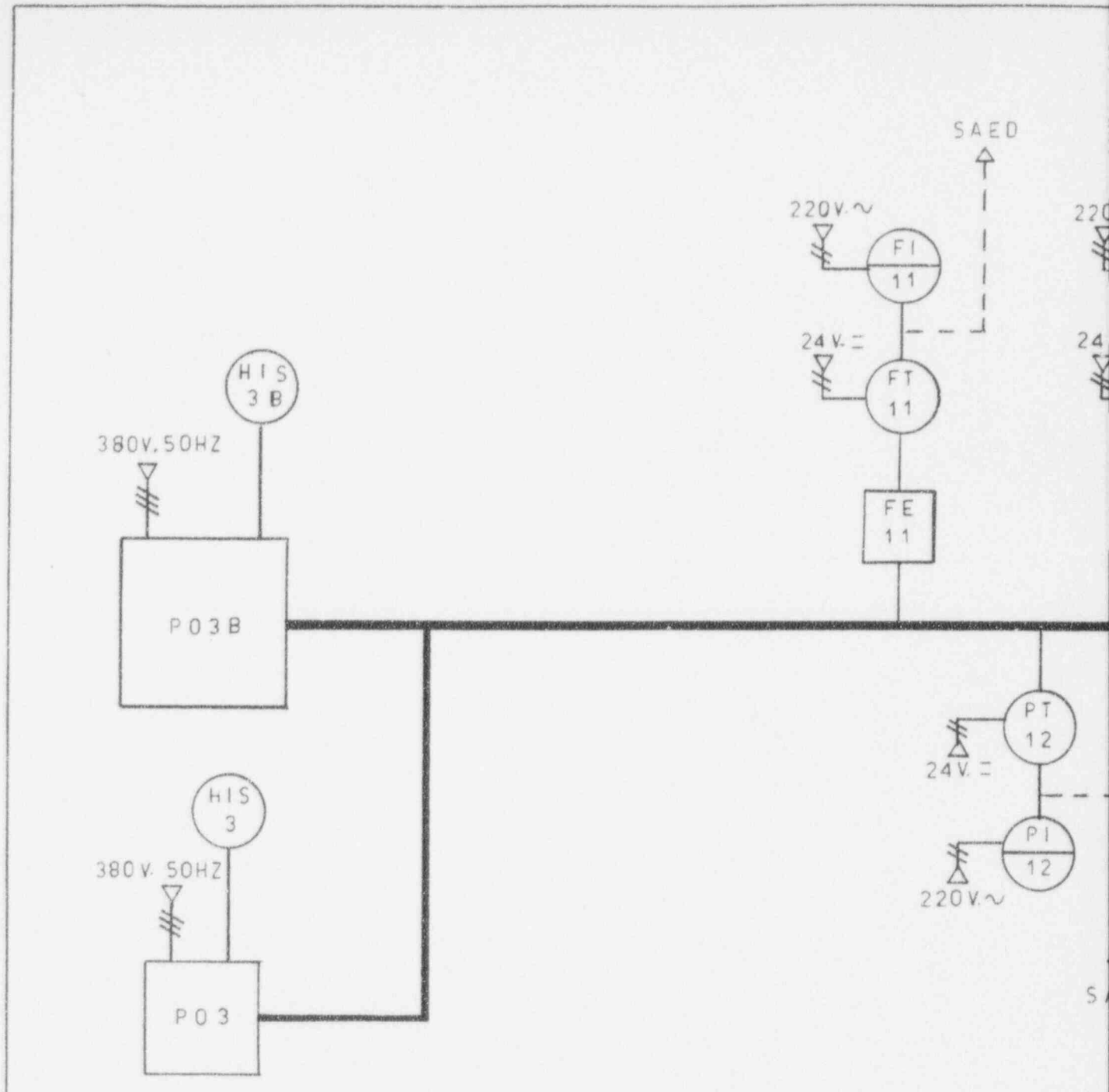



DIS. N° 2136335 - REV. 0 - 03/02/1994




PO 3 B = MAIN FAN POWER SUPPLY

PO 3 = AUXILIARY FAN POWER SUPPLY

HIS 3 B = MAIN FAN START + STOP

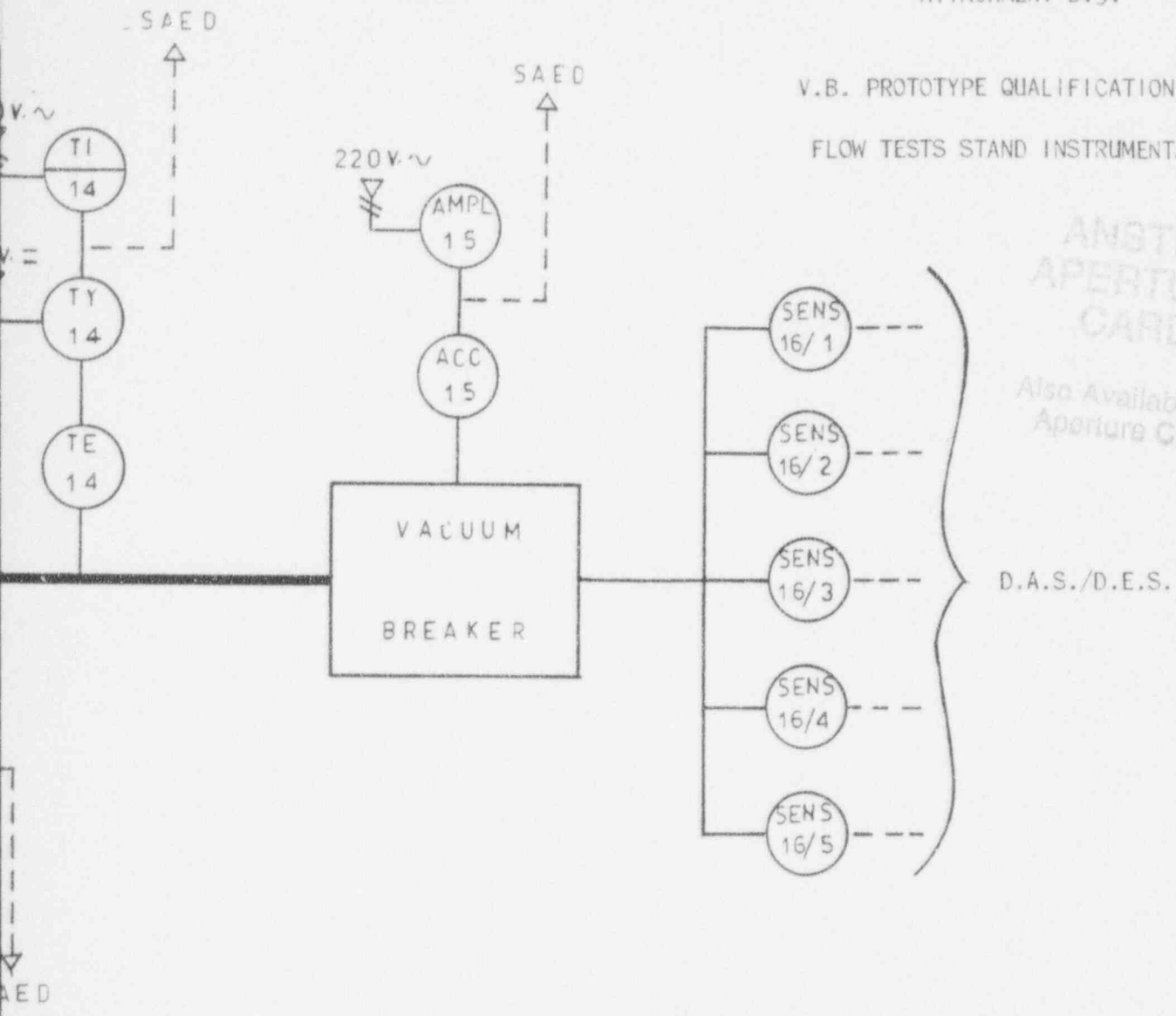
HIS 3 = AUXILIARY FAN START + STOP

F 11 = FLOW MEASUREMENT CHAIN

ATTACHMENT B.5.

V.B. PROTOTYPE QUALIFICATION TESTS

FLOW TESTS STAND INSTRUMENTATION






| | | |
|---|---|---|
| P 12 | = | PRESSURE MEASUREMENT CHAIN |
| T 14 | = | TEMPERATURE MEASUREMENT CHAIN |
| ACC 15 | = | ACCELERATION MEASUREMENT CHAIN |
| SENS 16/1÷5 | = | DISK DISPLACEMENTS MEASUREMENTS |
| D.A.S./D.E.S. | = | DATA ACQUISITION/ELABORATION SYSTEM |

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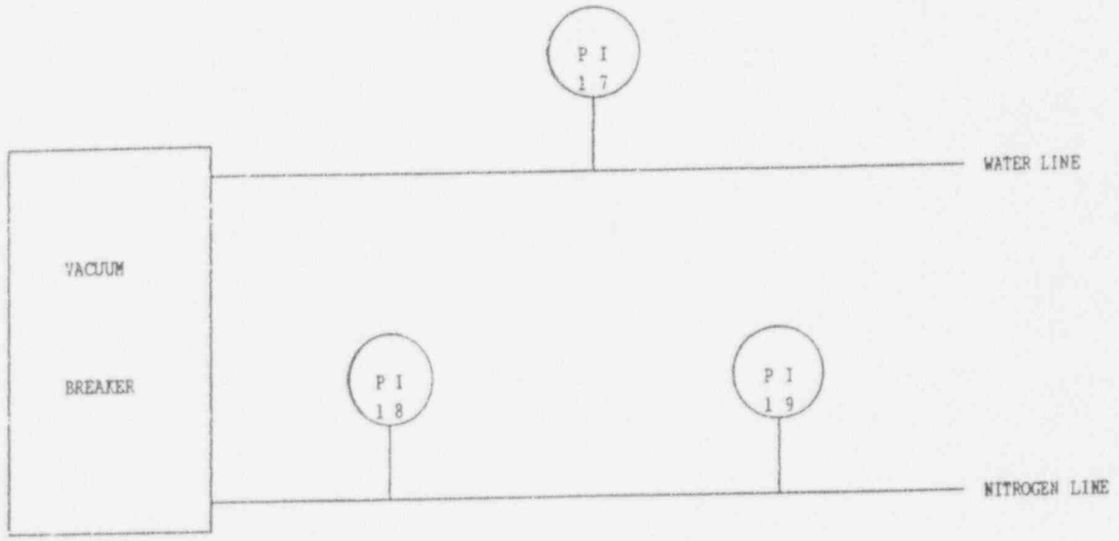



P I
2 0

T I
2 1

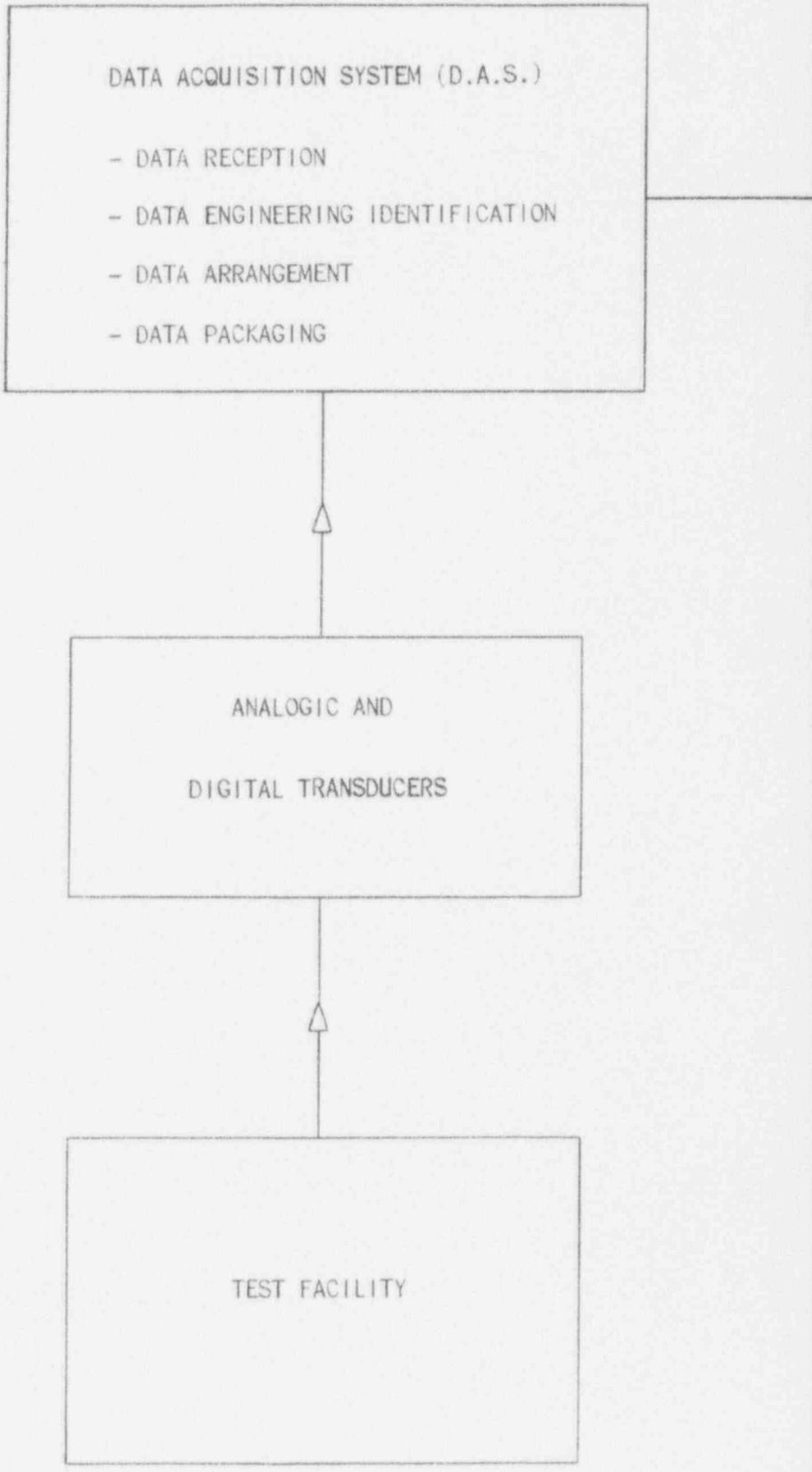
PI 17 = PRESSURE MEASUREMENT

PI 18 = PRESSURE MEASUREMENT

PI 19 = PRESSURE MEASUREMENT

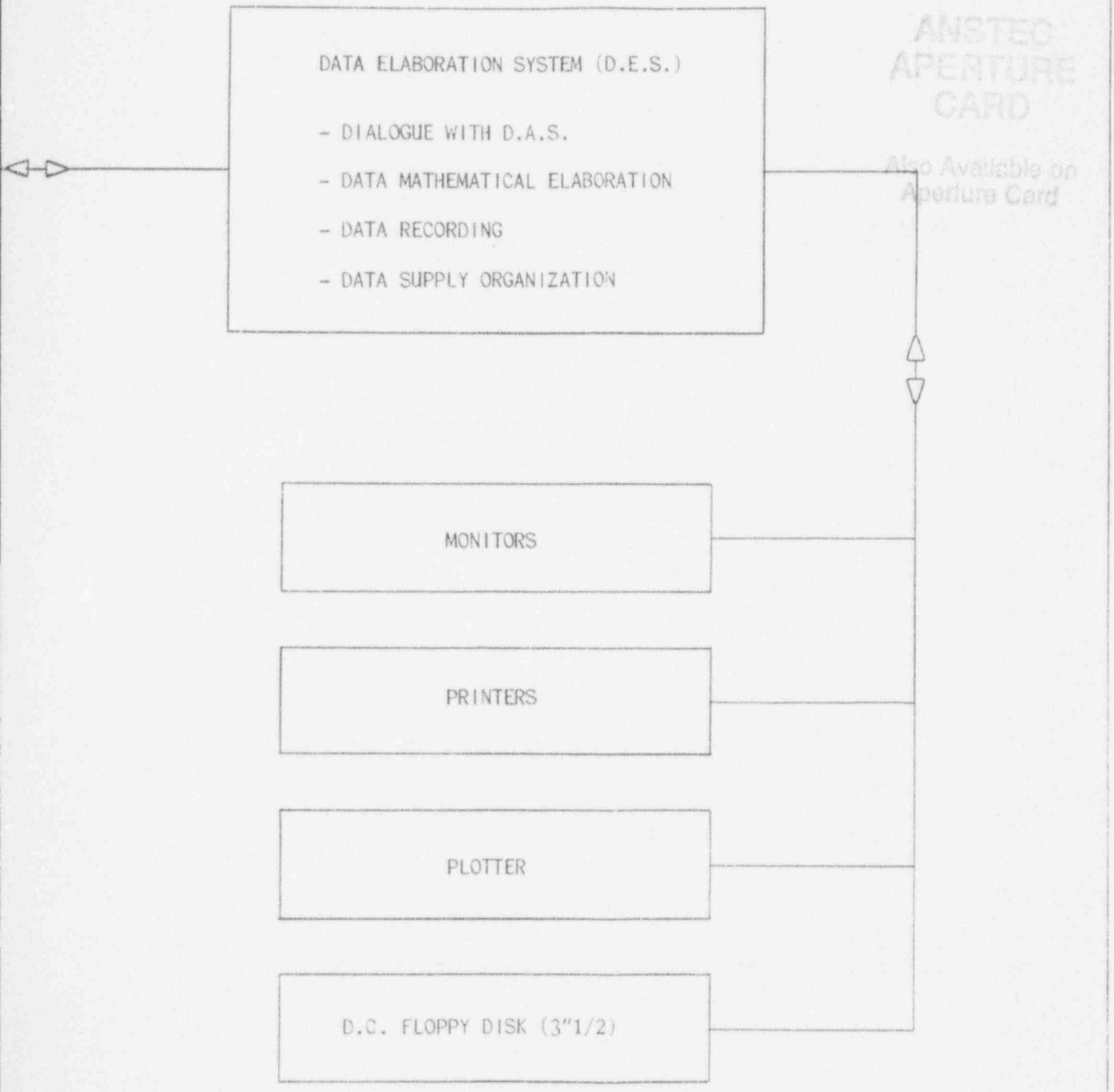
PI 20 = ATMOSPH. PRESS. MEASUR.

TI 21 = AMBIENT TEMPERAT. MEASUR.


DATA ACQUISITION SYSTEM (D.A.S.)
- DATA RECEPTION
- DATA ENGINEERING IDENTIFICATION
- DATA ARRANGEMENT
- DATA PACKAGING
ANALOGIC AND
DIGITAL TRANSDUCERS
TEST FACILITY

V.B. PROTOTYPE QUALIFICATION TESTS

FLOW TESTS DATA ACQUIS./ELAB. DIAGRAM



- TESTING FIRM: ..... CERTIFICATE N°: .....
  DATE: .....

- TEST FACILITY: LEAK TESTS STATION

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- TEST PROCEDURE: DOC. N° ED45834, REV. .....

- TEST MEDIUM: DEMINERALIZED WATER

- TOP PRESSURIZATION PHASE DATA:

| Nominal top pressure | Real top pressure | Pressurization time |
|---|---|---|
| 472 KPa | ..... KPa | ..... min |
| (67.5 psi) | (..... psi) | |

- LEAKAGE EXAMINATION PHASE DATA:

| Nominal pressure | Real pressure | Pressurization time |
|---|---|---|
| 357 KPa | ..... KPa | ..... min |
| (51 psi) | (..... psi) | |

ANNOTATIONS: .....
.....
.....
.....
.....
.....

- TEST RESULT: .....

- TEST CONDUCTOR: ..... G.E REPRESENTATIVE: .....

- TESTING FIRM: ..... CERTIFICATE N°: .....

  DATE: .....

- TEST FACILITY: LEAK TESTS STATION PAGE: 1/2

- TEST PROCEDURE: DOC. N° ED45834, REV. .....

  ED45833
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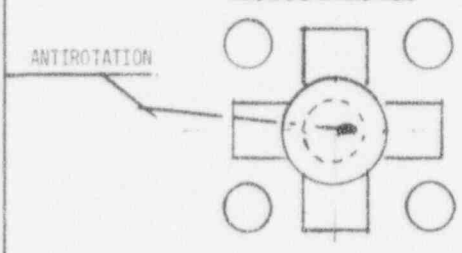
- TEST : BASELINE SYSTEMATIC

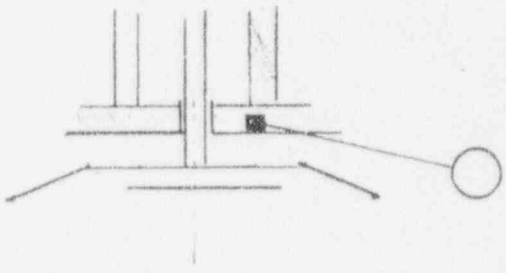
- PRECEDING OPERATIONS ON THE V.B.: .....

- PROBES IDENTIFICATION:

Lower Probes




Upper Probe



- ACCURACY/REPEATABILITY TESTS DATA:

**PROBE READINGS**

| PROBE N° | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEST N° | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| SHIMS THICKNESS 0.76 mm (30 mils) | | | | | | | | | | | | | | | |
| 1.018 mm (40 mils) | | | | | | | | | | | | | | | |
| 2.036 mm (80 mils) | | | | | | | | | | | | | | | |
| 2.54 mm (100 mils) | | | | | | | | | | | | | | | |
| 3.8 mm (150 mils) | | | | | | | | | | | | | | | |

CERTIFICATE N°: .....

DATE: .....

PAGE: 2/2

- PARTICLE TEST DATA:

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PROBE READINGS

| PROBE N° FEELER GAUGE | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1.52 mm (60 mils) | | | | | |
| 2.036 mm (80 mils) | | | | | |

- ANNOTATIONS:

. Accuracy/Repeatability Tests: .....
.....
.....
.....
.....
.....
.....
.....

. Particle Test: .....
.....
.....
.....
.....

- TEST RESULT: .....

- TEST CONDUCTOR: ..... G.E. REPRESENTATIVE .....

Mod. CIEI 9022 - Tip. GABO

## HARDSEAT BASELINE LEAK TEST

- TESTING FIRM: ..... CERTIFICATE N°: .....
  DATE: .....
  PAGE: 1/5
- TEST FACILITY: LEAK TESTS STATION
  ED45833
  Page 91
- TEST PROCEDURE: DOC. N° ED45834, REV. .....
- TEST MEDIUM: NITROGEN
- V.B. BODY DEPRESSURIZATION TESTS DATA:
  . Initial ambient temperature: ..... °C (.....°F)
  . Initial atmospheric pressure: ..... KPa (..... psi)
  . Depressurization history:

V.B. BODY PRESSURE — TIME

| 100 KPa (14 psi) | 1st Test 0.00 sec | 2nd Test 0.00 sec | 3rd Test 0.00 sec |
|---|---|---|---|
| 90 KPa (12.6 psi) | | | |
| 80 KPa (11.2 psi) | | | |
| 70 KPa (9.8 psi) | | | |
| 60 KPa (8.4 psi) | | | |
| 50 KPa (7 psi) | | | |

. Final Ambient Temperature: ..... °C (..... °F)
. Final Atmospheric Pressure: ..... KPa (..... psi)

## HARDSEAT BASELINE LEAK TEST

- MEAN LEAK RATES CALCULATION:..
  (SEE NOTE 1 )

CERTIFICATE N°: .....
DATE: .....
PAGE: 2/5

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V.B. BODY

MEAN LEAK RATES st.m³/sec (st.ft³/sec)

PRESSURE

| | 100÷ 90 KPa | 90÷80 KPa | 80÷70 KPa | 70÷60 KPa | 60÷50 KPa |
|---|---|---|---|---|---|
| | 14÷12.6psi | 12.6÷11.2psi | 11.2÷9.8psi | 9.8÷8.4psi | 8.4÷7 psi |
| 1st TEST | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) |
| 2nd TEST | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) |
| 3rd TEST | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) |

- HARD SEAT LEAK MEAN EQUIVALENTE AREAS (A/√K) CALCULATION (AT EACH DEPRESSURIZATION STEP):
  (SEE NOTE 2 )

V.B. BODY

MEAN EQUIVALENT AREAS m² (ft²)

MEAN PRESSURES

| | 95 KPa | 85 KPa | 75 KPa | 65 KPa | 55 KPa |
|---|---|---|---|---|---|
| | (13.3 psi) | (11.9 psi) | (10.5 psi) | (9.1 psi) | (7.7 psi) |
| 1st TEST | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) |
| 2nd TEST | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) |
| 3rd TEST | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) | ..... (.....) |

## HARDSEAT BASELINE LEAK TEST

- RESULTING HARDSEAT LEAK MEAN EQUIVALENT AREA CALCULATION (AT EACH TEST): (SEE NOTE 3 )

CERTIFICATE N°: .....
DATE: .....
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RESULTING MEAN EQUIVALENT AREA $m^2$ ($ft^2$)

| | |
|---|---|
| 1st TEST | ..... (.....) |
| 2nd TEST | ..... (.....) |
| 3rd TEST | ..... (.....) |

- FINAL HARDSEAT LEAK MEAN EQUIVALENT AREA CALCULATION: (SEE NOTE 4 )

$(A/\sqrt{K})_{HARDSEAT\ (FINAL)}$ = ..... $m^2$ (..... $ft^2$)

- TEST RESULT: .....

- TEST CONDUCTOR: ..... G.E. REPRESENTATIVE .....

## HARDSEAT BASELINE LEAK TEST

NOTES:

CERTIFICATE N°: .....

DATE: .....

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NOTE 1 : MEAN LEAK RATE CALCULATION ($Q_{MEAN}$) AT EACH DEPRESSURIZATION STEP (BEING AMBIENT TEMPERATURE AND ATMOSPHERIC PRESSURE PRACTICALLY CONSTANT DURING THE TESTS A SIMPLIFIED EXPRESSION FOR $Q_{MEAN}$ IS USED)

$$Q_{MEAN} = \frac{V \cdot (P_1 - P_2)}{(t_2 - t_1) \cdot P_{atm_o}} \cdot \frac{T_o}{T_{amb.}} \quad (st.m^3/sec)$$

WHERE:

V = V.B. INTERNAL VOLUME = ..... $m^3$ (..... $ft^3$)

$P_1$ = INITIAL V.B. INTERNAL RELATIVE PRESSURE (Pa)

$P_2$ = FINAL V.B. INTERNAL RELATIVE PRESSURE (Pa)

$t_1$ = DEPRESSURIZATION STEP INITIAL TIME (sec)

$t_2$ = DEPRESSURIZATION STEP FINAL TIME (sec)

$P_{atmo}$ = "STANDARD" ATMOSPHERIC PRESSURE = 760 mmHg = $1.01 \times 10^5$ Pa = 14.6 psi

To = "STANDARD" AMBIENT TEMPERATURE = 20°C = = 293°K = 68°F

$T_{amb}$ = TEST AMBIENT TEMPERATURE (°K)

## HARDSEAT BASELINE LEAK TEST

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NOTE 2 : MEAN EQUIVALENT AREA $(A/\sqrt{K})_{MEAN}$ CALCULATION AT EACH DEPRESSURIZATION STEP:

$$(A/\sqrt{K})_{MEAN} = Q_{MEAN} \cdot \sqrt{\frac{\rho_o}{2 \cdot P_{mean}}} \quad (m^2)$$

WHERE:

$Q_{MEAN}$ = MEAN LEAK RATE (SEE NOTE 1 ) ($st.m^3/sec$)

$\rho_o$ = "STANDARD" AIR DENSITY, AT 760 mmHg ATMOSPHERIC PRESSURE AND 293°K AMBIENT TEMPERATURE = = 1.205 $kg/m^3$ = 7.55 x $10^{-2}$ $lb/ft^3$

$P_{MEAN}$ = MEAN V.B. INTERNALL RELATIVE PRESSURE DURING THE STEP (Pa)

NOTE 3 : RESULTING MEAN EQUIVALENT AREA CALCULATION AT EACH TEST:

$$\left(\frac{A}{\sqrt{K}}\right)_{\substack{MEAN \\ RES.}} = \frac{1}{5} \cdot \sum_{1}^{5} \left(\frac{A}{\sqrt{K}}\right)_{MEAN}$$

NOTE 4 : FINAL MEAN EQUIVALENT AREA CALCULATION:

$$\left(\frac{A}{\sqrt{K}}\right)_{\substack{HARDSEAT \\ FINAL}} = \frac{1}{3} \cdot \sum_{1}^{3} \left(\frac{A}{\sqrt{K}}\right)_{\substack{MEAN \\ RES.}}$$

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## DISK SEAL BUBBLE LEAK TEST

- TESTING FIRM: ..... CERTIFICATE N°: .....

  DATE: .....

- TEST FACILITY: LEAK TESTS STATION PAGE: 1/2

- TEST PROCEDURE: DOC. N° ED45834, REV. .....

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- TEST MEDIUM: NITROGEN

- TEST KIND : [BASELINE] [SYSTEMATIC]

- PRECEDING OPERATIONS ON THE V.B.: .....

- [BASELINE] TEST DATA:

| | 1st TEST | 2nd TEST | 3rd TEST |
|---|---|---|---|
| V.B. BODY PRESSURIZATION (NOMINAL) | 245 KPa (35 psi) | 245 KPa (35 psi) | 245 KPa (35 psi) |
| V.B. BODY PRESSURIZATION (REAL) | ... KPa (... psi) | ... KPa (... psi) | ... KPa (... psi) |
| LEAK STABILIZATION WAIT TIME | ..... | ..... | ..... |
| BUBBLES COUNTING PERIOD | ..... | ..... | ..... |
| N° OF BUBBLES COUNTED | ..... | ..... | ..... |
| RESULTING LEAK RATE (1 BUBBLE $\simeq$ 0.15 cc) | ..... cc/sec | ..... cc/sec | ..... cc/sec |

## DISK SEAL BUBBLE LEAK TEST

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- SYSTEMATIC TEST DATA:

CERTIFICATE N°: .....
DATE: .....
PAGE: 2/2

| V.B. BODY PRESSURIZATION | TEST N° | LEAK STABILIZ. WAIT TIME | BUBBLES COUNTING PERIOD | N° OF BUBBLES COUNTED | RESULTING LEAK RATE (1 bubble = ≃ 0.15 cc |
|---|---|---|---|---|---|
| 20.5 KPa (3 psi) | 1 | | | | cc/sec |
| | 2 | | | | cc/sec |
| | 3 | | | | cc/sec |
| 41 KPa (6 psi) | 1 | | | | cc/sec |
| | 2 | | | | cc/sec |
| | 3 | | | | cc/sec |
| 69 KPa (10 psi) | 1 | | | | cc/sec |
| | 2 | | | | cc/sec |
| | 3 | | | | cc/sec |
| 103 KPa (15 psi) | 1 | | | | cc/sec |
| | 2 | | | | cc/sec |
| | 3 | | | | cc/sec |

- TEST RESULT: .....

- TEST CONDUCTOR: ..... G.E. REPRESENTATIVE .....

## DISK SEAL PRESSURE LOSS LEAK TEST

- TESTING FIRM: ..... CERTIFICATE N°: .....
  DATE: .....
- TEST FACILITY: LEAK TESTS STATION PAGE: 1/5
- TEST PROCEDURE: DOC. N° ED45834, REV. .....
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- TEST MEDIUM: NITROGEN
- PRECEDING OPERATIONS ON THE V.B.: .....

  . Particles under soft seal:

  [ PRESENT ] [ ABSENT ]

  . Particles diameter: ..... mm (..... mils)
- TEST DATA:

INITIAL V.B. BODY PRESSURIZATION (RELATIVE)

| DATA | TEST N° | 20.5 KPa (3 psi) | 41 KPa (6 psi) | 69 KPa (10 psi) | 103 KPa (15 psi) |
|---|---|---|---|---|---|
| INITIAL AMBIENT TEMPERATURE (°K) | 1 | | | | |
| | 2 | | | | |
| | 3 | | | | |
| INITIAL ATMOSPH. PRESSURE (Pa) | 1 | | | | |
| | 2 | | | | |
| | 3 | | | | |
| DEPRESSURIZATION WAIT TIME (sec) | 1 | | | | |
| | 2 | | | | |
| | 3 | | | | |
| FINAL V.B. BODY PRESSURIZATION (Pa rel) | 1 | | | | |
| | 2 | | | | |
| | 3 | | | | |
| FINAL AMBIENT TEMPERATURE (°K) | 1 | | | | |
| | 2 | | | | |
| | 3 | | | | |
| FINAL ATMOSPH. PRESSURE (Pa) | 1 | | | | |
| | 2 | | | | |
| | 3 | | | | |

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## DISK SEAL PRESSURE LOSS LEAK TEST

- MEAN V.B. BODY PRESSURIZATIONS ($P_{MEAN}$) CERTIFICATE N°: .....
  AND MEAN LEAK RATES ($Q_{MEAN}$) DATE: .....
  IDENTIFICATION: PAGE: 2/5
  (SEE NOTES 1 and 2 )

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| V.B. BODY INITIAL PRESSURIZATION | TEST N° | MEAN V.B. BODY PRESSURIZATION | MEAN LEAK RATE |
|---|---|---|---|
| 20.5 KPa ( 3 psi) | 1 | | stcc/sec |
| | 2 | | stcc/sec |
| | 3 | | stcc/sec |
| 41 KPa ( 6 psi) | 1 | | stcc/sec |
| | 2 | | stcc/sec |
| | 3 | | stcc/sec |
| 69 KPa (10 psi) | 1 | | stcc/sec |
| | 2 | | stcc/sec |
| | 3 | | stcc/sec |
| 103 KPa (15 psi) | 1 | | stcc/sec |
| | 2 | | stcc/sec |
| | 3 | | stcc/sec |

## DISK SEAL PRESSURE LOSS LEAK TEST

- RESULTING MEAN V.B. BODY PRESSURIZATIONS ($P_{MEAN\ RES.}$) AND MEAN LEAK RATES ($Q_{MEAN\ RES.}$) CALCULATION:
  (SEE NOTE 3 )

CERTIFICATE N°: .....
DATE: .....
PAGE: 3/5

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| V.B. BODY INITIAL PRESSURIZATION | RESULTING MEAN V.B. BODY PRESSURIZATION | RESULTING MEAN LEAK RATE |
|---|---|---|
| 20.5 KPa<br>( 3 psi) | ..... KPa<br>(..... psi) | ..... stcc/sec |
| 41 KPa<br>( 6 psi) | ..... KPa<br>(..... psi) | ..... stcc/sec |
| 69 KPa<br>( 10 psi) | ..... KPa<br>(..... psi) | ..... stcc/sec |
| 103 KPa<br>( 15 psi) | ..... KPa<br>(..... psi) | ..... stcc/sec |

- TEST RESULT: .....
  (COMPARISON WITH ATTACHMENT B.10-4 OF DOC. N° ED 45834)

- TEST CONDUCTOR: ..... G.E. REPRESENTATIVE: .....

## DISK SEAL PRESSURE LOSS LEAK TEST

NOTES:

CERTIFICATE N°: .....

DATE: .....

PAGE: 4/5

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NOTE 1 : MEAN V.B. BODY
PRESSURIZATION CALCULATION AT EACH TEST:

$$P_{MEAN} = 1/2 \ (P_{INITIAL} + P_{FINAL})$$

NOTE 2 : MEAN LEAK RATE
CALCULATION AT EACH TEST:

$$Q_{MEAN} = \frac{V}{(t_2 - t_1) \cdot P_{atm_0}} \cdot \left[ \left( P_1 + P_{atm_1} \right) \cdot \frac{\overline{T_0}}{T_1} - \left( P_2 + P_{atm_2} \right) \frac{\overline{T_0}}{T_2} \right]$$

(stcc/sec)

WHERE:

$V$ = V.B. INTERNAL VOLUME (cc)
$t_1$ = INITIAL TEST TIME (sec)
$t_2$ = FINAL TEST TIME (sec)
$P_1$ = INITIAL V.B. BODY PRESSURIZATION (Pa relative)
$P_2$ = FINAL V.B. BODY PRESSURIZATION (Pa relative)
$T_1$ = INITIAL AMBIENT TEMPERATURE (°K)
$T_2$ = FINAL AMBIENT TEMPERATURE (°K)
$P_{atm1}$ = INITIAL ATMOSPHERIC PRESSURE (Pa)
$P_{atm2}$ = FINAL ATMOSPHERIC PRESSURE (Pa)

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DISK SEAL PRESSURE LOSS LEAK TEST

CERTIFICATE N°: .....

DATE: .....

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$P_{atmo.}$ = "STANDARD" ATMOSPHERIC PRESSURE = 760 mmHg =
= $1.01 \times 10^5$ Pa = 14.6 psi

To = "STANDARD" AMBIENT TEMPERATURE = 20°C =
= 293°K = 68°F

NOTE 3 : RESULTING MEAN V.B. BODY PRESSURIZATION AND MEAN LEAK RATE CALCULATION:
(AT EACH INITIAL PRESSURIZATION LEVEL)

$$\left(P_{\substack{MEAN \\ RES}}\right) = \frac{1}{3} \cdot \sum_{1}^{3} \left(P_{MEAN}\right)$$

$$\left(Q_{\substack{MEAN \\ RES.}}\right) = \frac{1}{3} \cdot \sum_{1}^{3} \left(Q_{MEAN}\right)$$

## MAXIMUM ACCEPTABLE LEAK RATES

## FROM V.B. DISK SEAL

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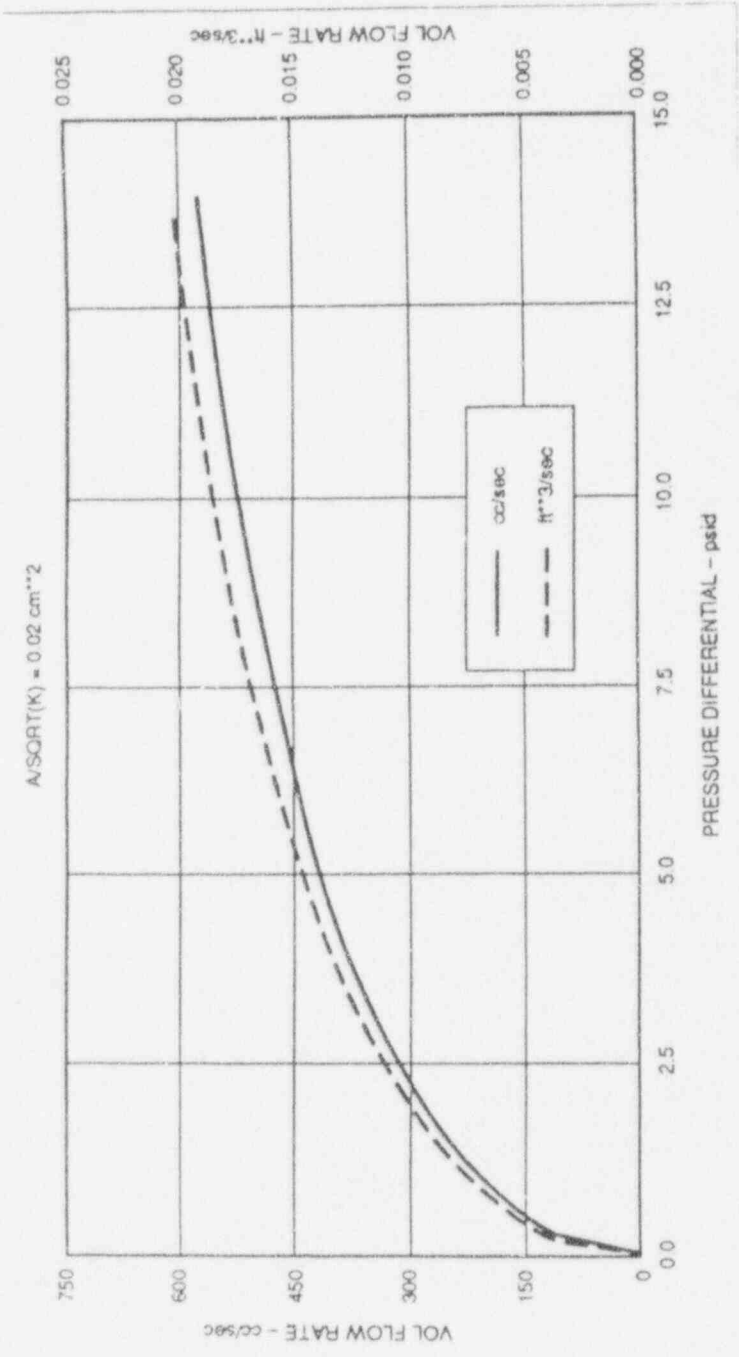

## DISK ASSEMBLY LIFT FORCE

- TESTING FIRM: ..... CERTIFICATE N°: .....
  DATE: .....
- TEST FACILITY: .....
- TEST PROCEDURE: DOC. N° ED45834, REV. ..... ED45833 Page 104
- TEST KIND : [ BASELINE ] [ SYSTEMATIC ]
- PRECEDING OPERATIONS ON THE V.B.: .....
- TEST DATA:

| READING N° | LIFT FORCE N (lb) |
|---|---|
| 1 | .....<br>(.....) |
| 2 | .....<br>(.....) |
| 3 | .....<br>(.....) |

ANNOTATIONS: .....
.....
.....
.....
.....
.....

- TEST RESULT: .....
- TEST CONDUCTOR : ..... G.E REPRESENTATIVE: .....

## LOW FLOW V.B. PERFORMANCES

- TESTING FIRM: ..... CERTIFICATE N°: .....
  DATE: .....
- TEST FACILITY: FLOW TESTS STAND PAGE: 1/2
- TEST PROCEDURE: DOC. N° ED45834, REV. .....
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- TEST MEDIUM: AIR
- TEST DATA SUMMARY:

. ANTICHATTERING DEVICE: [PRESENT] [ABSENT]

. DAMPER: [PRESENT] [ABSENT]

| DATA | TEST N° | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| AIR TEMPERATURE (°K) | ..... | ..... | ..... | ..... | ..... |
| ATMOSPH. PRESSURE (Pa) | ..... | ..... | ..... | ..... | ..... |
| INITIAL PROBES READINGS | | | | | |
| - PROBE 1 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 2 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 3 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 4 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 5 | ..... | ..... | ..... | ..... | ..... |
| LIFT PRESSURE (KPa) | ..... | ..... | ..... | ..... | ..... |
| | (.....) | (.....) | (.....) | (.....) | (.....) |
| OPENING TIME (sec) | ..... | ..... | ..... | ..... | ..... |
| CHATTERING | YES NO | YES NO | YES NO | YES NO | YES NO |
| V.B. OPEN PROBES READINGS | | | | | |
| - PROBE 1 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 2 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 3 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 4 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 5 | ..... | ..... | ..... | ..... | ..... |

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## LOW FLOW V.B. PERFORMANCES

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- TEST DATA SUMMARY: (CONTINUED)

CERTIFICATE N°: .....
DATE: .....
PAGE: 2/2

| DATA | TEST N° | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| MAX ESTABLISHED AIR FLOW ($m^3$/sec) | ..... | ..... | ..... | ..... | ..... |
| | (..... $ft^3$/sec) | (..... $ft^3$/sec) | (..... $ft^3$/sec) | (..... $ft^3$/sec) | (..... $ft^3$/sec) |
| CLOSING PRESSURE (KPa) | ..... | ..... | ..... | ..... | ..... |
| | (...psi) | (...psi) | (...psi) | (...psi) | (...psi) |
| CLOSING TIME (sec) | ..... | ..... | ..... | ..... | ..... |
| CHATTERING | YES NO | YES NO | YES NO | YES NO | YES NO |
| V.B. CLOSED PROBES READINGS | | | | | |
| - PROBE 1 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 2 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 3 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 4 | ..... | ..... | ..... | ..... | ..... |
| - PROBE 5 | ..... | ..... | ..... | ..... | ..... |

ANNOTATIONS: .....
.....
.....
.....
.....
.....

- TEST RESULT: .....

- TEST CONDUCTORS: ..... G.E REPRESENTATIVE: .....

## FULL FLOW V.B. PERFORMANCES

- TESTING FIRM: ..... CERTIFICATE N°: .....

  DATE: .....

- TEST FACILITY: FLOW TESTS STAND PAGE: 1/2

- TEST PROCEDURE: DOC. N° ED45834, REV. .....

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- TEST MEDIUM: AIR

- TEST DATA SUMMARY:

  . Air temperature: ..... °K

  . Atmospheric pressure: ..... Pa

  . V.B. lift pressure : ..... KPa (..... psi)

  . V.B. opening time : ..... sec

  . V.B. full flows data:

| DIFFERENTIAL PRESSURE | FLOWS $M^3$/SEC ($FT^3$/SEC) | | |
|---|---|---|---|
| | 1st TEST | 2nd TEST | 3rd TEST |
| 400 mm $H_2O$ (0.57 psid) | | | |
| 450 mm $H_2O$ (0.64 psid) | | | |
| 500 mm $H_2O$ (0.71 psid) | | | |
| 550 mm $H_2O$ (0.79 psid) | | | |
| 600 mm $H_2O$ (0.86 psid) | | | |
| 650 mm $H_2O$ (0.93 psid) | | | |
| 700 mm $H_2O$ ( 1 psid) | | | |

FULL FLOW V.B. PERFORMANCES

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- V.B. FULL FLOWS DATA: CERTIFICATE N°: .....

(CONTINUED) DATE: .....

PAGE: 2/2

| DIFFERENTIAL PRESSURE | FLOWS $M^3$/SEC ($FT^3$/SEC) | | |
|---|---|---|---|
| | 1st TEST | 2nd TEST | 3rd TEST |
| 650 mm $H_2O$ (0.93 psid) | | | |
| 600 mm $H_2O$ (0.86 psid) | | | |
| 550 mm $H_2O$ (0.79 psid) | | | |
| 500 mm $H_2O$ (0.71 psid) | | | |
| 450 mm $H_2O$ (0.64 psid) | | | |
| 400 mm $H_2O$ (0.57 psid) | | | |

- V.B. CLOSING PRESSURE: ..... KPa (..... psi)

- V.B. CLOSING TIME: ..... sec.

- TEST RESULT: .....

(COMPARISON WITH ATTACHMENT B.12-2 OF DOC. N° ED 45834)

- TEST CONDUCTORS: ..... G.E REPRESENTATIVE: .....

## MINIMUM ACCEPTABLE FLOW RATES

## ACROSS THE V.B.

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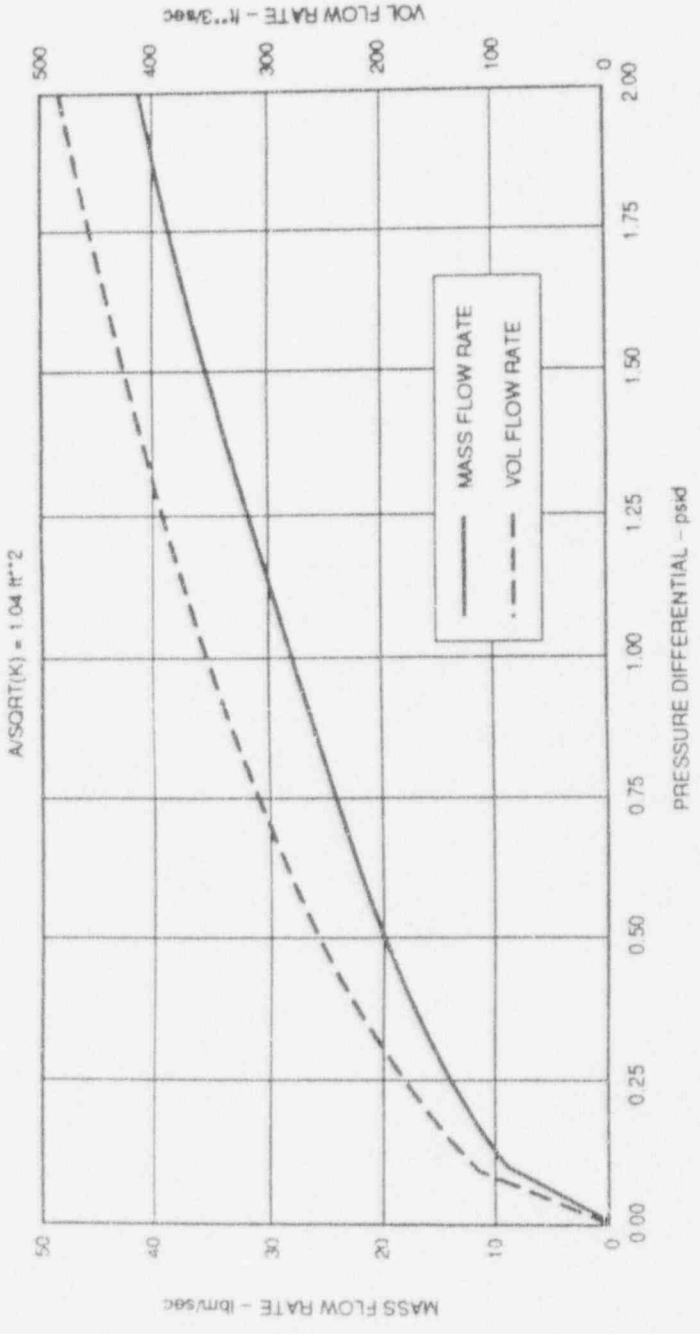

- TESTING FIRM: .....  CERTIFICATE N°: .....

  DATE: .....

- TEST FACILITY: FLOW TESTS STAND  PAGE: 1/2

- TEST PROCEDURE: DOC. N° ED45834, REV. .....

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- TEST MEDIUM: AIR

- SAMPLE TEST DATA:

| DATE | STROKE N° | LIFT PRESSURE | OPENING TIME | STABILIZED DIFFERENT. PRESSURE | STABILIZED FLOW | CLOSING TIME |
|---|---|---|---|---|---|---|
| | 1 | | | | | |
| | 100 | | | | | |
| | 200 | | | | | |
| | 300 | | | | | |
| | 400 | | | | | |
| | 500 | | | | | |
| | 600 | | | | | |
| | 700 | | | | | |
| | 800 | | | | | |
| | 900 | | | | | |
| | 1000 | | | | | |
| | 1100 | | | | | |
| | 1200 | | | | | |
| | 1300 | | | | | |
| | 1400 | | | | | |

- SAMPLE TEST DATA: ED45833 Page 111 (CONTINUED)

CERTIFICATE N°: .....

DATE: .....

PAGE: 2/2

| DATE | STROKE N° | LIFT PRESSURE | OPENING TIME | STABILIZED DIFFERENT. PRESSURE | STABILIZED FLOW | CLOSING TIME |
|---|---|---|---|---|---|---|
| | 1500 | | | | | |
| | 1600 | | | | | |
| | 1700 | | | | | |
| | 1800 | | | | | |
| | 1900 | | | | | |
| | 2000 | | | | | |
| | 2100 | | | | | |
| | 2200 | | | | | |
| | 2300 | | | | | |
| | 2400 | | | | | |
| | 2500 | | | | | |
| | 2600 | | | | | |
| | 2700 | | | | | |
| | 2800 | | | | | |
| | 2900 | | | | | |
| | 3000 | | | | | |

ANNOTATIONS: .....
.....
.....
.....
.....
.....

- TEST RESULT: .....

- TEST CONDUCTORS: ..... G.E REPRESENTATIVE: .....

FIAT COMPONENTI E IMPIANTI PER L'ENERGIA E L'INDUSTRIA S.p.A.

DIVISIONE **CIEI**

# CERTIFICATO DI CONTROLLO

## INSPECTION CERTIFICATE

cc N. _____

Foglio / sheet _____

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**Fabbricazione** / Manufacturing _____

**Cliente** / Customer _____ **Fornitura** / Order _____

**Oggetto** / Object _____ **Disegno** / Drawing _____

**Materiale** / Material _____ **Manufatto** / Manufactured _____

**Piano di Controllo** / Control plan _____ **Fase** / Phase _____ **Pagina** / Page _____

**Specifica di controllo** / Control specification _____ **Livello di accettazione** / Acceptance standard _____

**CARATTERISTICHE DELL'ESAME**
DATA EXAMINATION

**Zone esaminate:** / Control estension: _____

**Risultato:** / Result: [1] **Accettabile** / Accettable [2] **Non accettabile** / Unaccettable

**Note** / Remarks

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ATTACHMENT N° B.14

V.B. PROTOTYPE QUALIFICATION TESTS

EXPERTISE CERTIFICATE

| Data / Date | Eseguito da: / Performed by: | | Ispettore FIAT | | Ispettore Cliente / Customer Inspector | Enti collaudatori / Surveyors |
|---|---|---|---|---|---|---|
| | | Liv.-Lev. | | Liv.-Lev. | | |

Mod. CIEI 10041