GENERAL ELECTRIC

NUCLEAR POWER

SYSTEMS DIVISION

GENERAL ELECTRIC COMPANY, 175 CURTNER AVE., SAN JOSE, CALIFORNIA 95125

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MFN 276-79

November 15, 1979

U.S. Nuclear Regulatory Commission
Division of Project Management
Office of Nuclear Reactor Regulation
Washington, D.C. 20555

Attention: Denwood F. Ross, Jr., Deputy Director

SUBJECT: SMALL BREAK GUIDELINE TRAINING SEMINAR

The subject seminar was held on November 7-8, 1979 for the purpose of instructing the utility personnel responsible for emergency procedure preparation and training in the philosophy and considerations underlying the Small Break Accident guidelines developed by the BWR Owners Group.

In a November 2, 1979 telecon with S. T. Rogers (BWR Owners Group) and P. W. Marriott (GE), Wayne Hodges of your staff requested a copy of the handout material used at the seminar. In response to this request, a copy is attached.

The final SBA guidelines will be transmitted to you by General Electric on behalf of the BWR Owners Group on November 16, 1979, in conformance with our mutually agreed upon schedule.

Very truly yours,

R H Buchholz

R. H. Buchholz, Manager
BWR Systems Licensing
Safety and Licensing Operation

RHB:bjr/1042

cc: L. S. Gifford

Attachments

G006 S/1 ENCL TO: FILES NRC PDR TERA I&E (6) ALL OTHERS RECEIVE LTR ONLY

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NCC

OBJECTIVE OF ANALYSES

- DEMONSTRATE EXPECTED SYSTEM RESPONSE

- DEMONSTRATE CONTINUITY IN THE SMALL BREAK SPECTRUM CURVE

- VERIFY OPERATOR ACTIONS IN GUIDELINES

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DESCRIPTION OF SAFE CODE USED IN SBA ANALYSIS

- SAFE MODELS VESSEL RESPONSE TO LOCA
  - VESSEL PRESSURE VS TIME
  - VESSEL INVENTORY (WATER LEVEL) VS TIME
  - ECC SYSTEM INITIATION AND FLOW RATES
- THERMODYNAMIC MODELLING
  - FIVE FLUID REGIONS
  - FUEL NODES PROVIDE HEAT SOURCES
  - INTERNAL AND VESSEL HEAT SLAB NODING
  - CORE AND BYPASS MODELLED AS ONE REGION
- UP TO FIVE BREAKS CAN BE MODELLED AT ONE TIME
  - INSIDE OR OUTSIDE THE SHROUD
  - ANY ELEVATION

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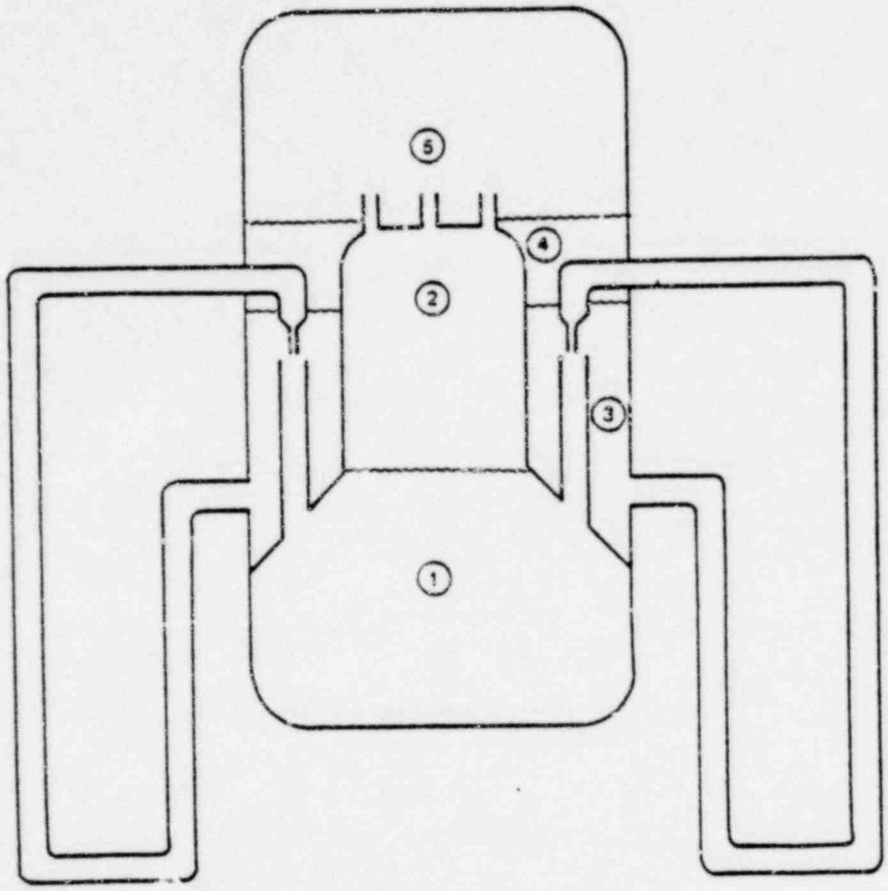

INITIAL CONDITIONS OF REGIONS

(1) SUBCOOLED LIQUID INSIDE SHROUD

(2) SATURATED MIXTURE INSIDE SHROUD

(3) SUBCOOLED LIQUID OUTSIDE SHROUD

(4) SATURATED LIQUID OUTSIDE SHROUD

(5) SATURATED VAPOR IN STEAM DOME

DESCRIPTION OF SAFE CODE USED IN SBA ANALYSIS (CONTINUED)

POOR ORIGINAL

- ECC SYSTEMS
  - FLOW RATES OF ALL ECCS
    HPCI, HPCS, LPCI, LPCS, IC, RCIC, CRD,
    FWCI, ADS
  - ECC SYSTEM INITIATION ON LOW WATER LEVEL
    OR HIGH DRYWELL PRESSURE (INPUT)
- STEAMLINE FLOW
  - PRESSURE CONTROLLER MODEL
  - MSIV CLOSURE
- RECIRCULATION FLOW
  - NATURAL CIRCULATION COMPONENT
  - PUMPED FLOW COMPONENT
  - PUMP COASTDOWN
- SIMPLE FEEDWATER CONTROLLER MODEL
  (WATER LEVEL ONLY)

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ASSUMPTIONS USED IN ANALYSIS

- 1978 ANS DECAY HEAT
- CALCULATIONS START AT NORMAL WATER LEVEL
- SCRAM, HIGH PRESSURE ECCS INITIATE ON HIGH DRYWELL PRESSURE
- OFFSITE POWER IS ASSUMED AVAILABLE
- NON-SAFETY GRADE SYSTEMS ASSUMED AVAILABLE
  - CONTROL ROD DRIVE FLOW
  - REACTOR CORE ISOLATION COOLING
  - CONDENSATE
- MORE REALISTIC HEAT TRANSFER COEFFICIENTS ASSUMED

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ANALYSIS APPROACH

- MOST CASES RUN FOR FITZPATRICK (BWR/4-218)
- OTHER PLANTS RUN WHEN SYSTEM DIFFERENCES MIGHT AFFECT SYSTEM RESPONSE

SEQUENCE OF CALCULATIONS

- ALL SYSTEMS
- DEGRADED CASES

  RCIC + CRD
  HPCI/HPCS
  FEEDWATER
  LOW PRESSURE ONLY

- ADDRESSED OTHER CONCERNS

  NO BREAK WITH ISOLATION
  STUCK OPEN RELIEF VALVE (SORV)

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CATEGORIES OF BREAK TYPES

I. PRESSURIZED

- ISOLATED AND AVAILABLE HP SYSTEMS FLOW GREATER THAN BREAK FLOW

II. PRESSURE HANGUP

- AVAILABLE HP SYSTEMS FLOW APPROXIMATELY EQUAL TO BREAK FLOW

III. DEPRESSURIZE

- AVAILABLE HP SYSTEMS FLOW LESS THAN BREAK FLOW

- RANGE OF STEAM BREAKS

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ALL SYSTEMS

- HIGH PRESSURE SYSTEMS MAINTAIN LEVEL
- SLOW DEPRESSURIZATION
- HANDLES BOTH LIQUID AND STEAM BREAKS
- ABOVE RESPONSES TYPICAL OF ALL PRODUCT LINES

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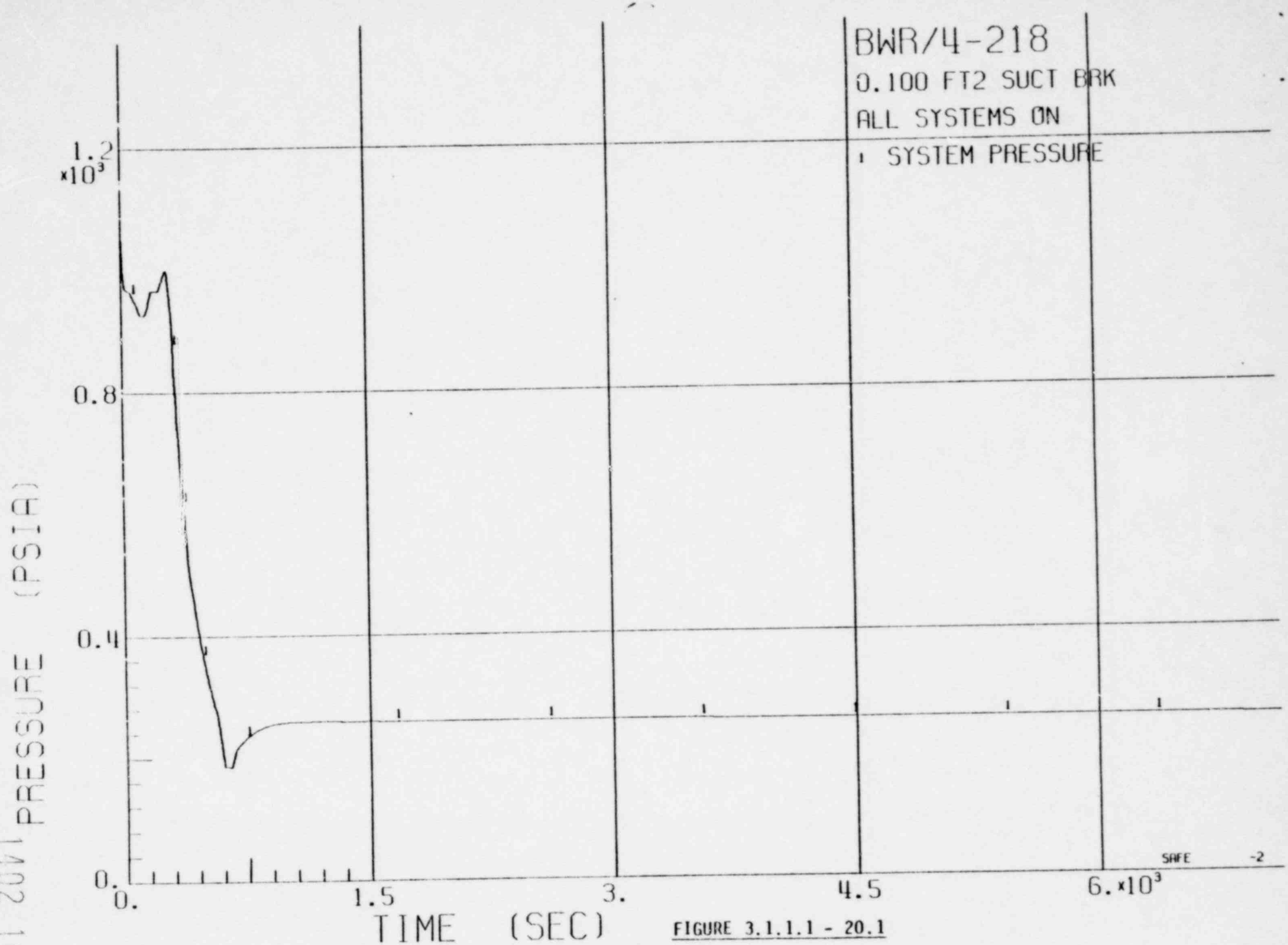

FIGURE 3.1.1.1 - 20.1

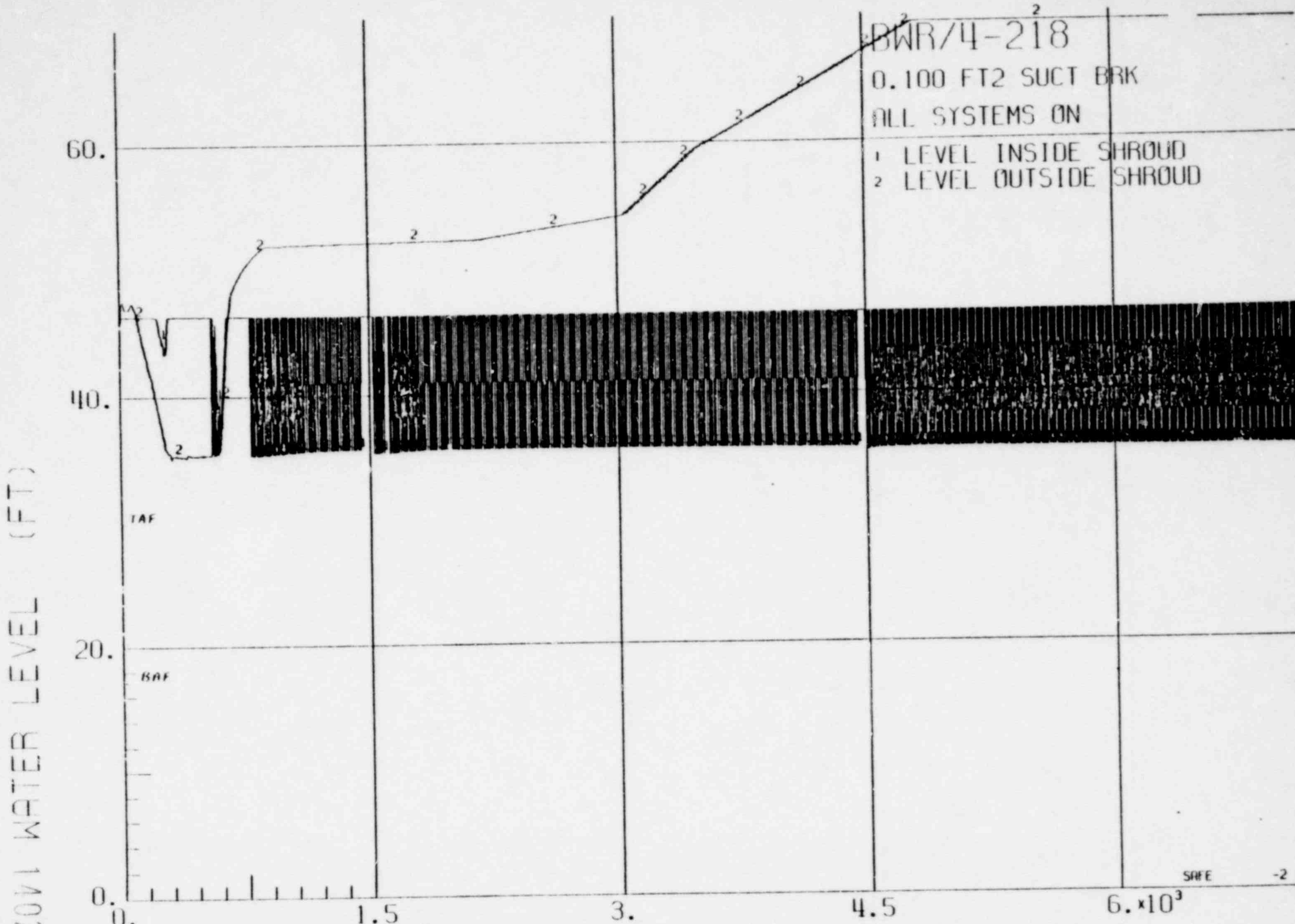

FIGURE 3.1.1.1 - 20.2

1402 108

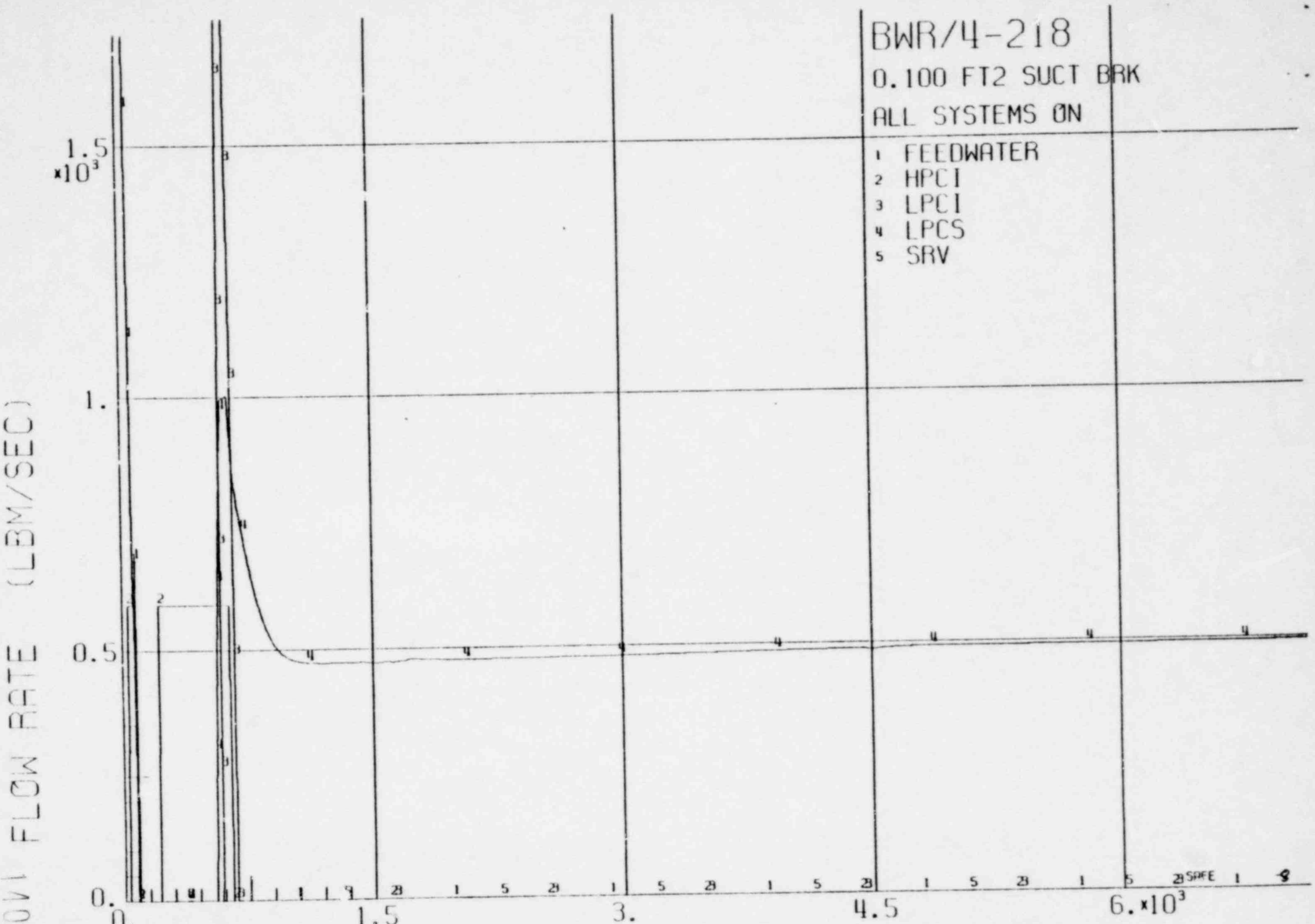

FIGURE 3.1.1.1 - 20.3

1402 109

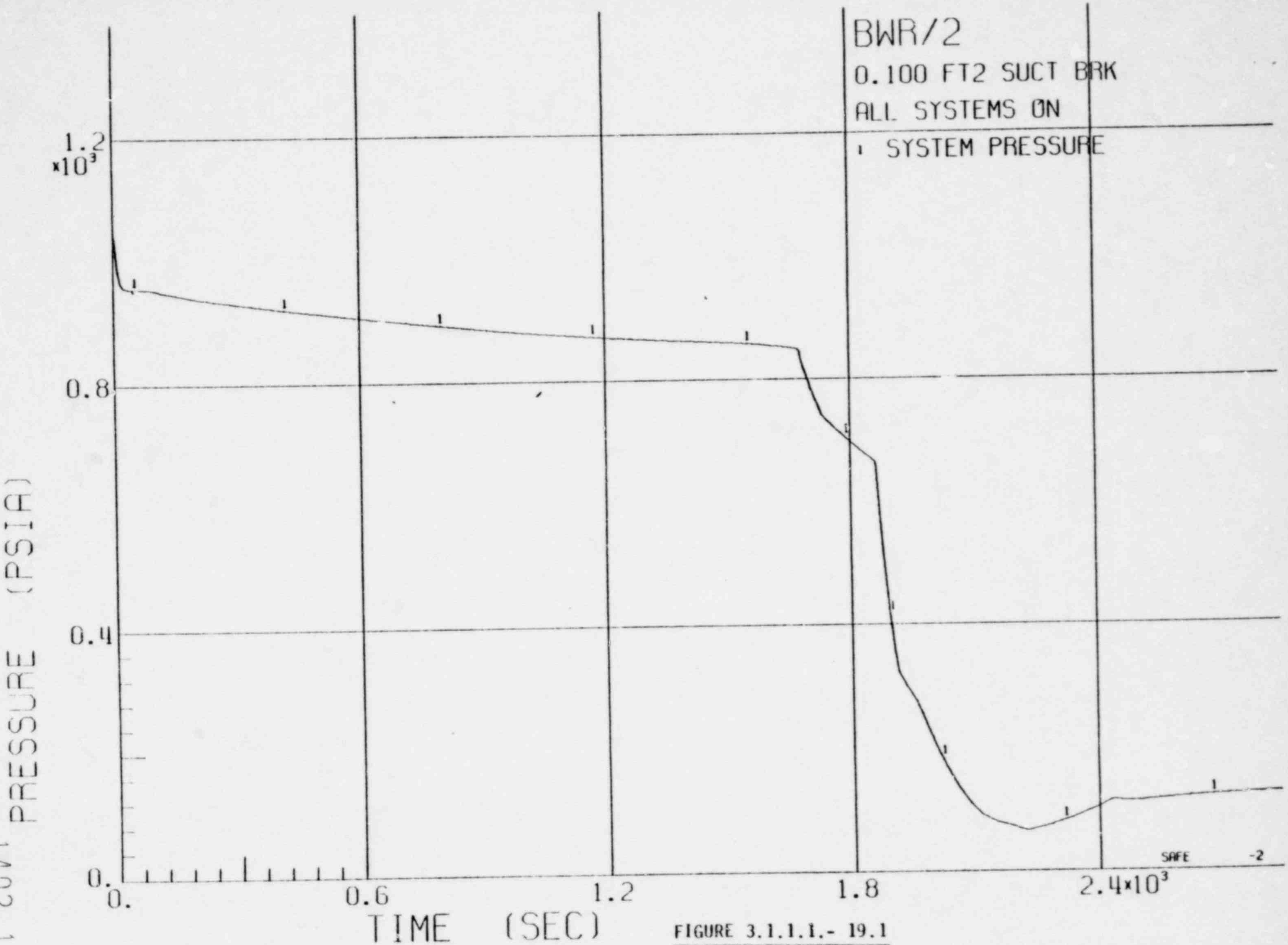

FIGURE 3.1.1.1.- 19.1

1402 110

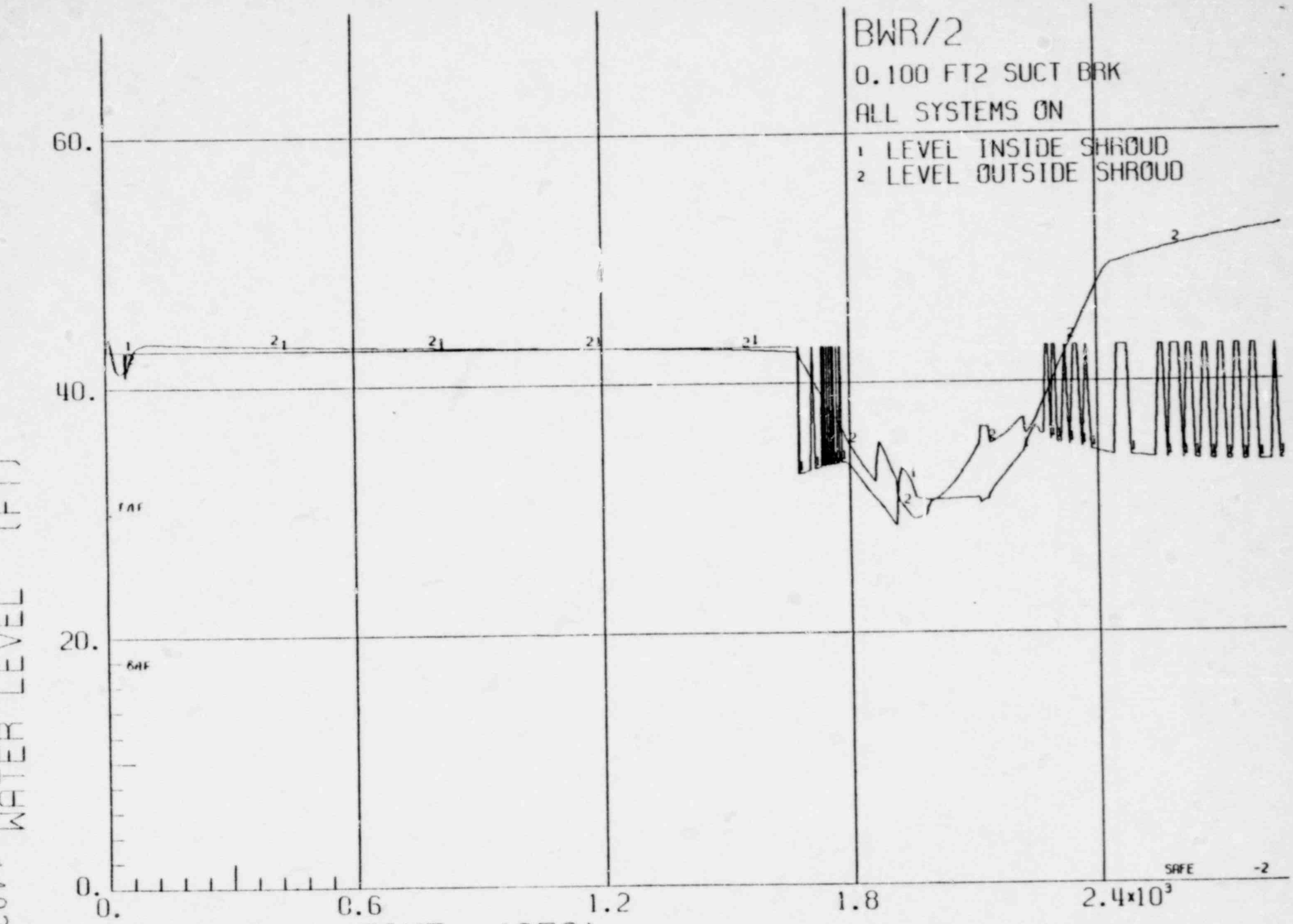

FIGURE 3.1.1.1 - 19.2

1402 111

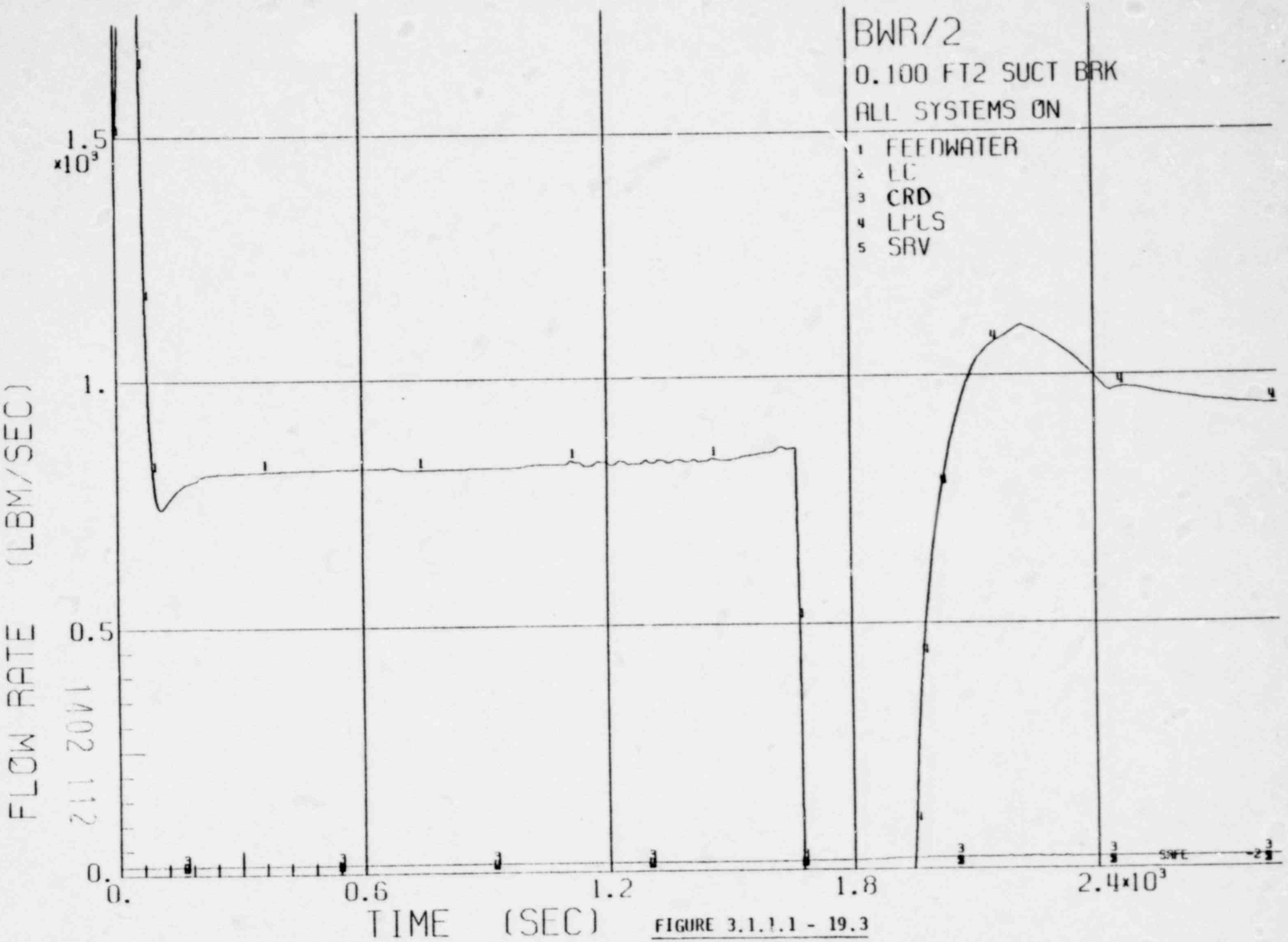

FIGURE 3.1.1.1 - 19.3

1402 112

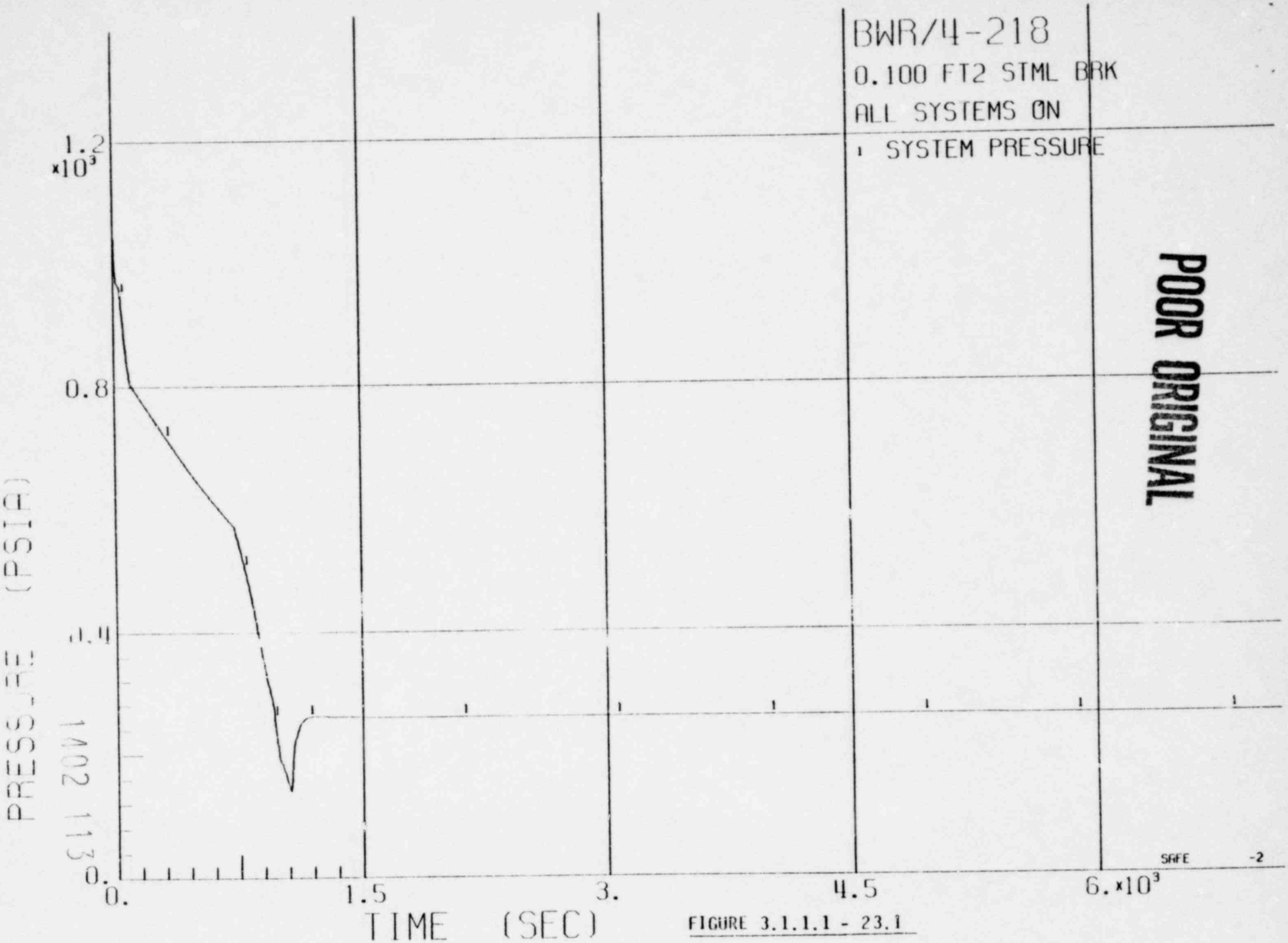

FIGURE 3.1.1.1 - 23.1

1402 113

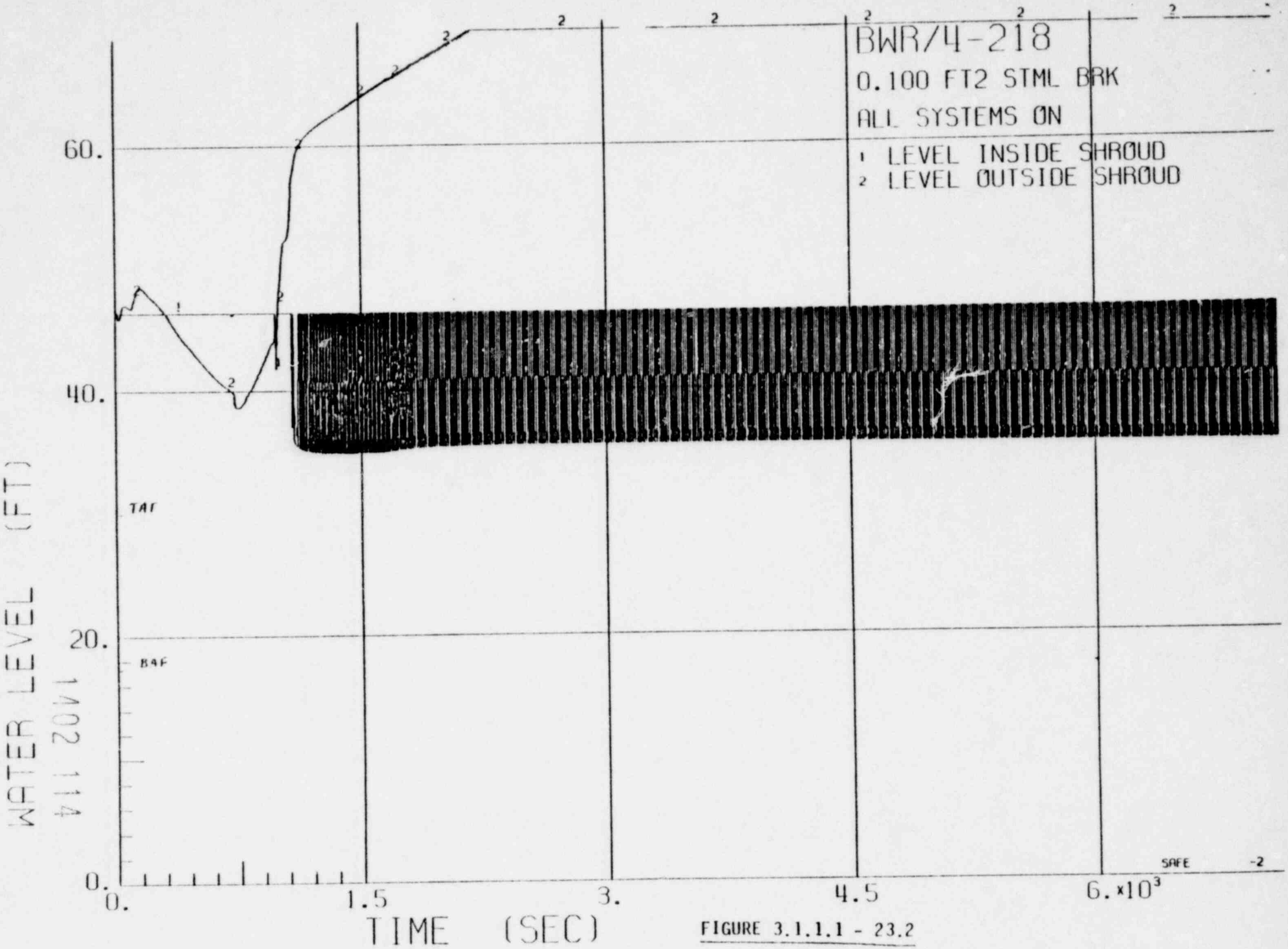

FIGURE 3.1.1.1 - 23.2

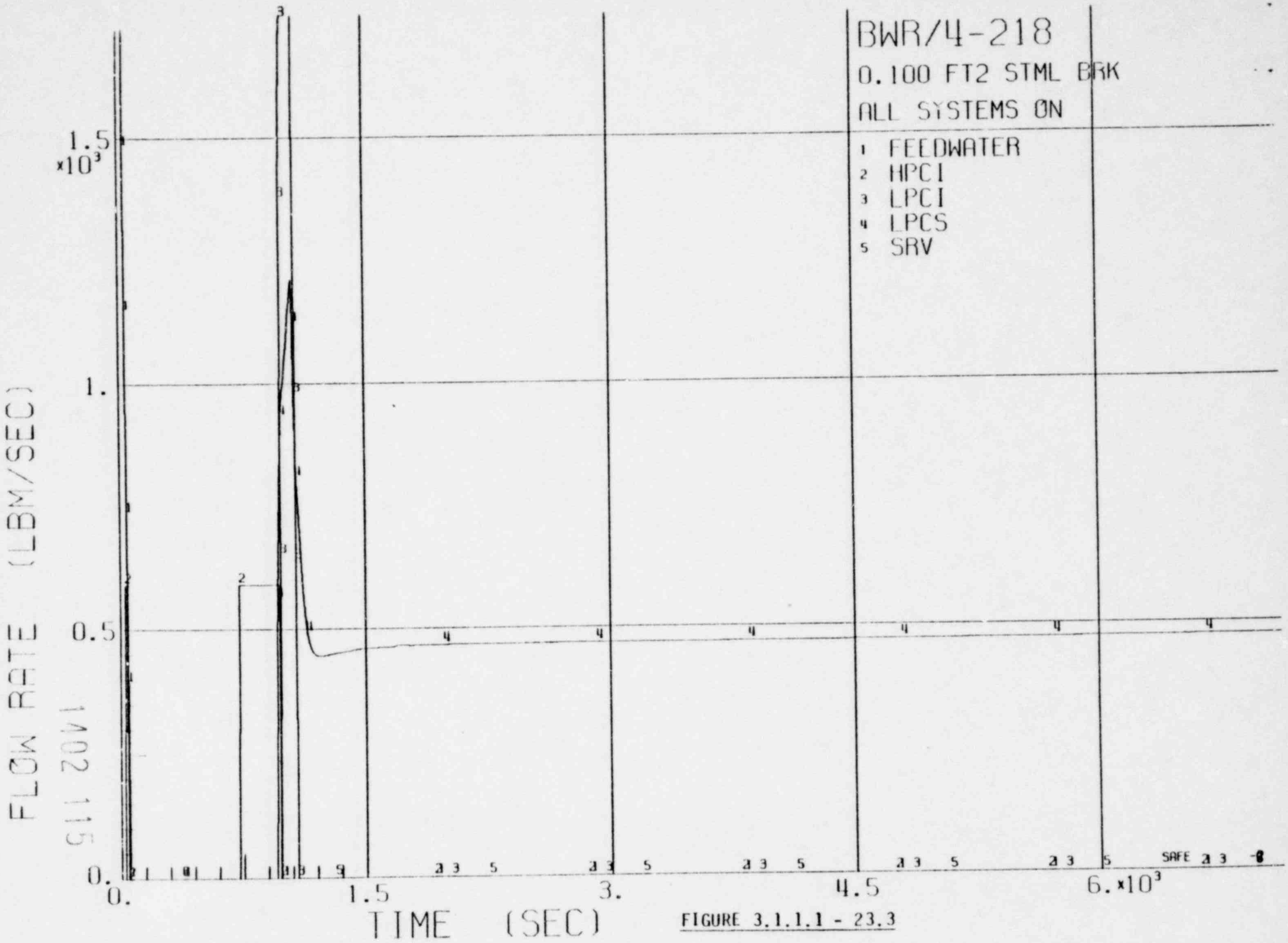

FIGURE 3.1.1.1 - 23.3

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OPERATOR ACTIONS

ALL SYSTEMS OPERATING

- VERIFY THAT SYSTEM IS MAINTAINING LEVEL

- THROTTLE HIGH PRESSURE SYSTEMS

- THROTTLE LOW PRESSURE SYSTEMS

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DEGRADED CASE MATRIX

	RCIC/EC + CRD	HPCI/HPCS	FW	LP ONLY
RECRC(SUCT)	.0001 - .02	.005 - .1	.05 - .2	.001 - .2
RECRC(DSCG)	.005	-	-	-
FW(IN)	.005	.08	.1	-
CS(IN)	.005	-	-	-
STM(IN)	.0001 - .08	.05 - .2	.5 - 1.0	.1
STM(OUT)	.001 - .1	.001 - .5	1.0	.5

1402 117

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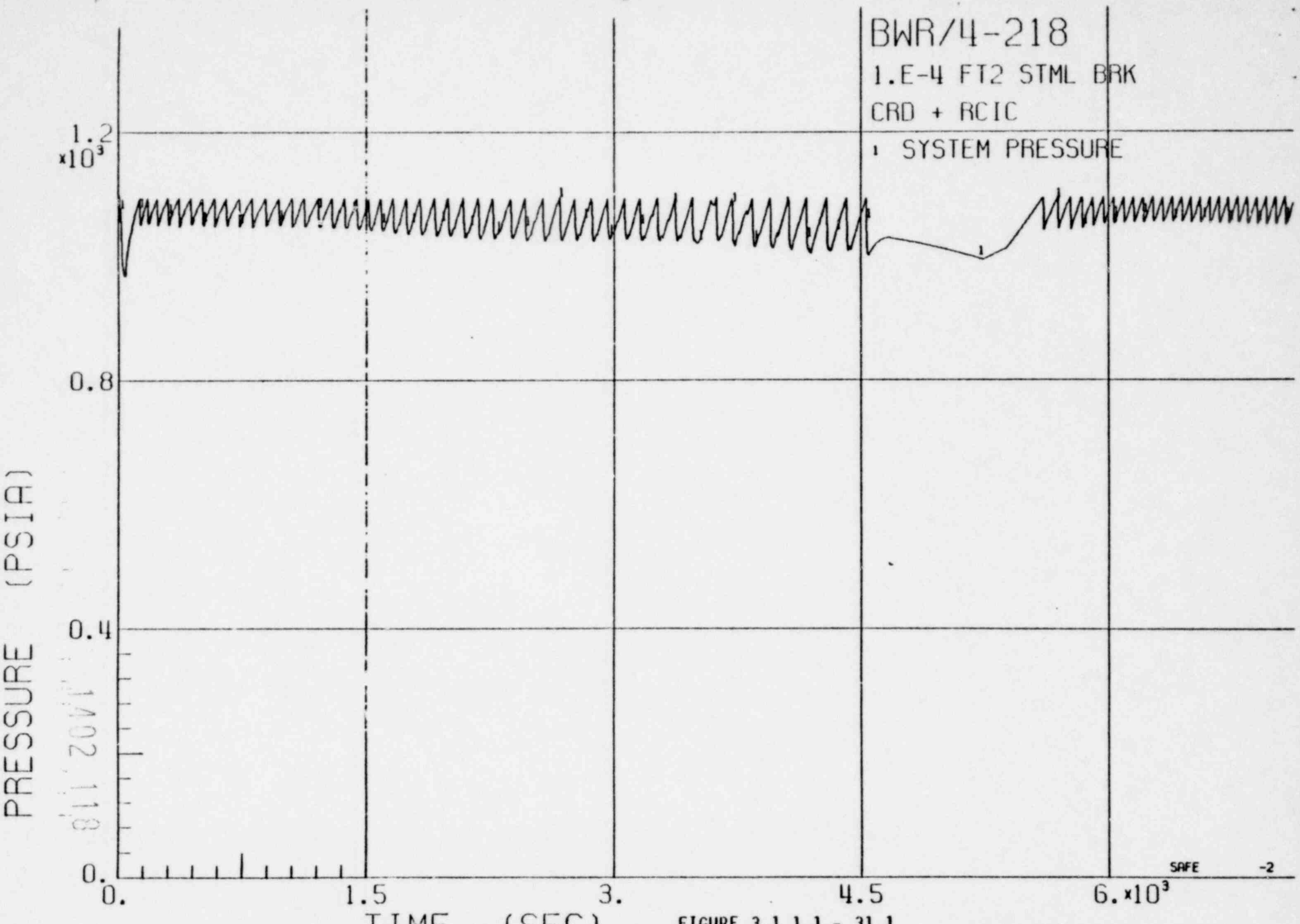


FIGURE 3.1.1.1 - 31,1

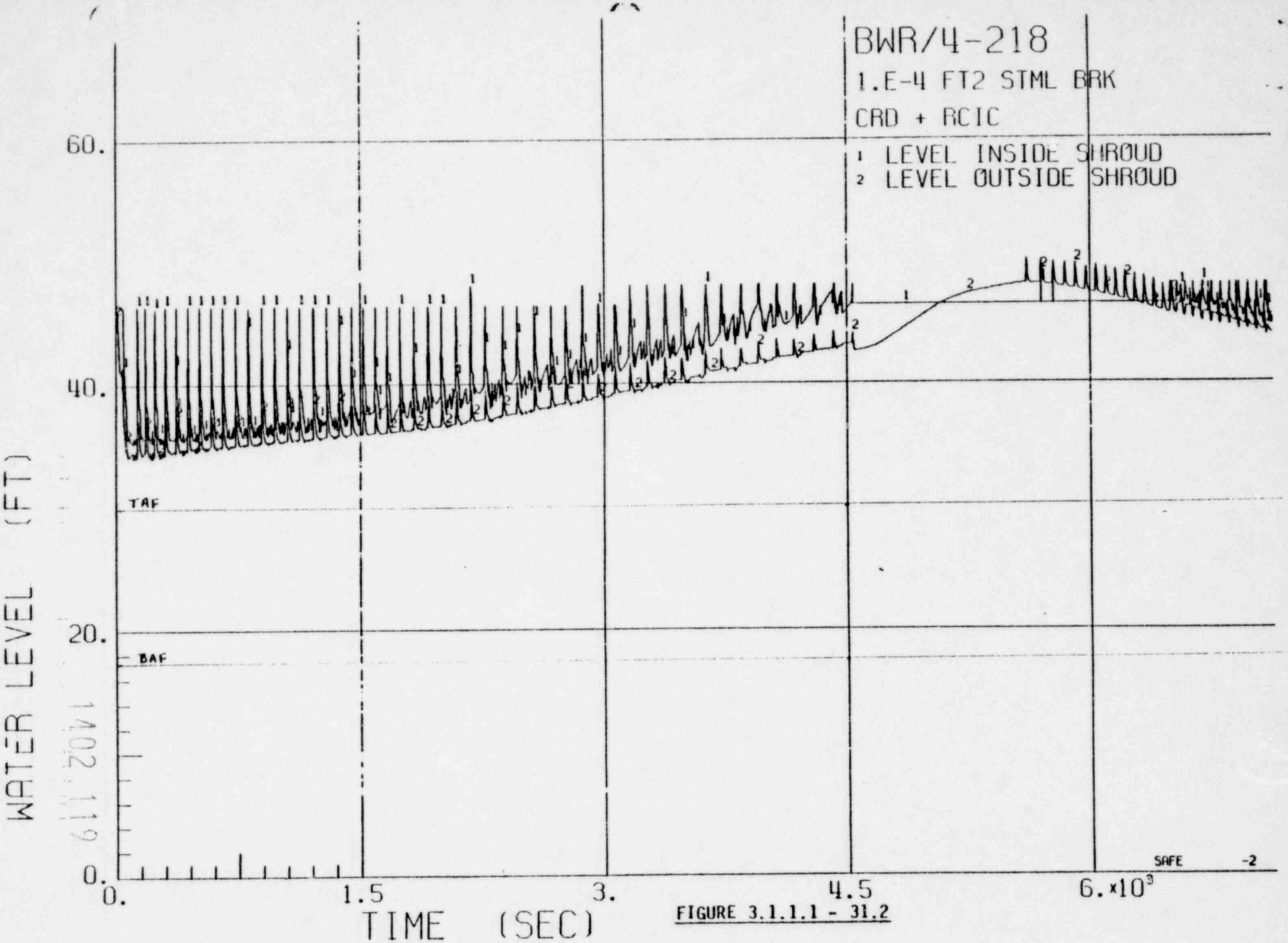


FIGURE 3.1.1.1 - 31.2

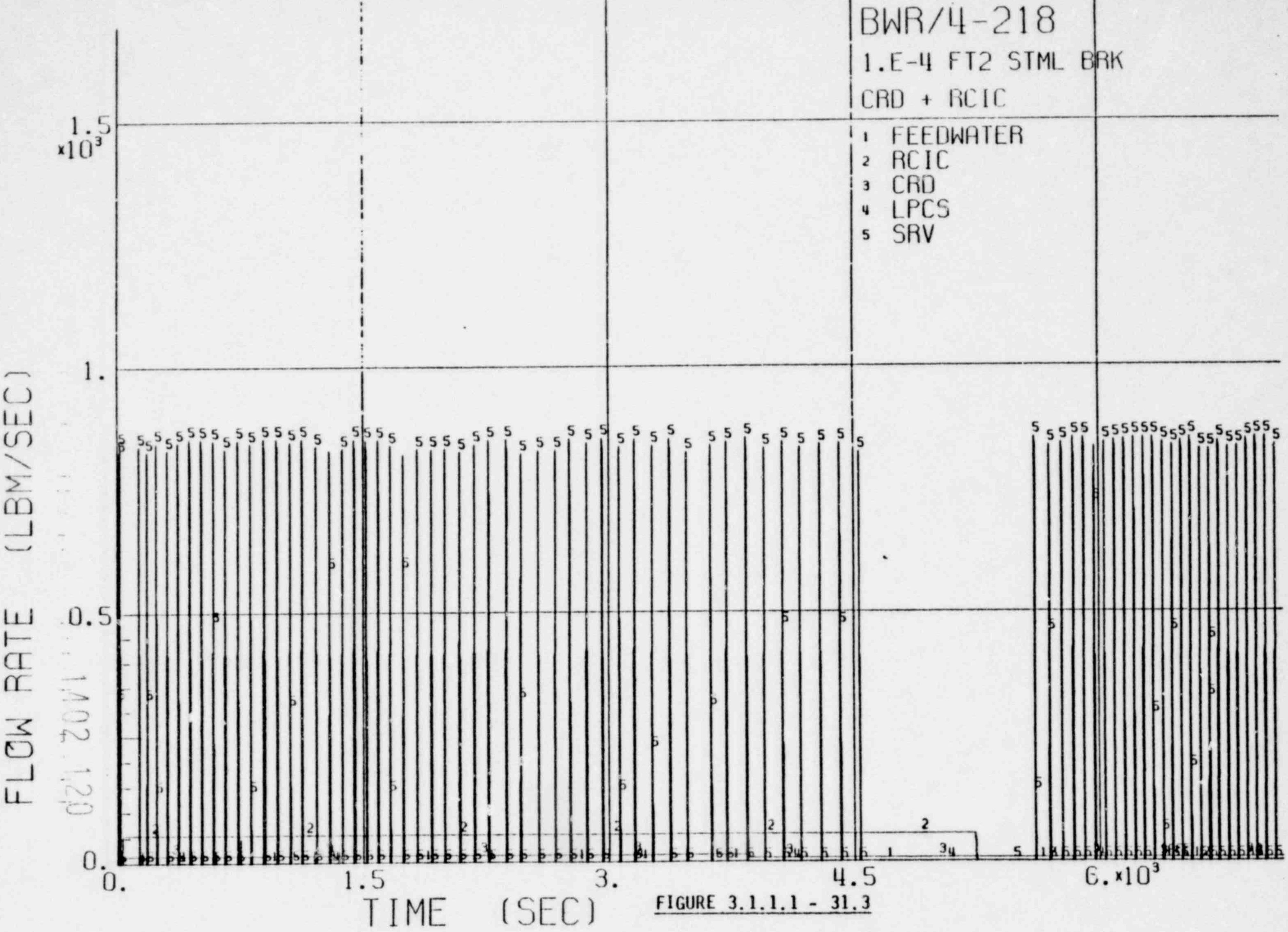


FIGURE 3.1.1.1 - 31.3

1402 120

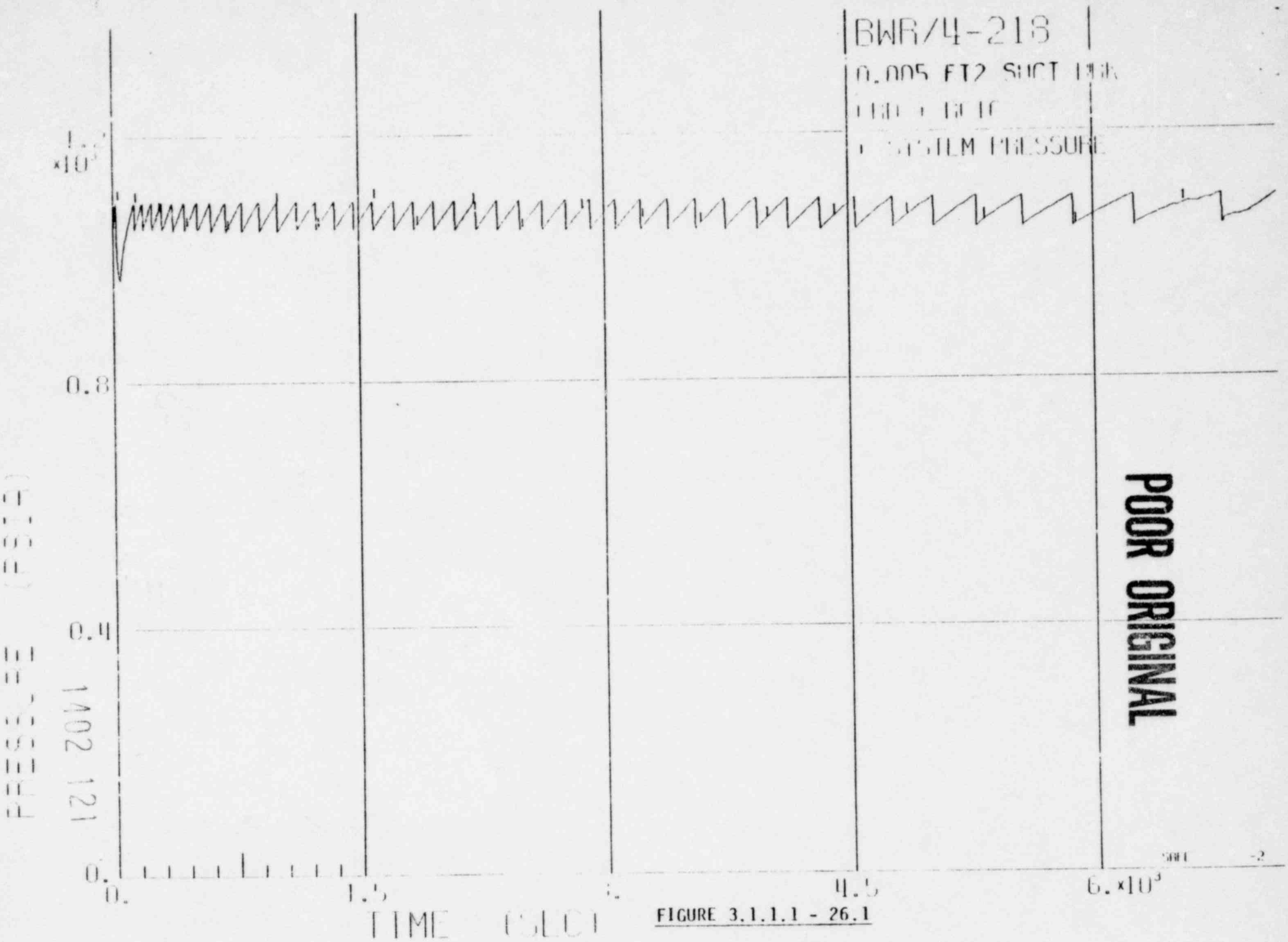


FIGURE 3.1.1.1 - 26.1

POOR ORIGINAL

1402 121

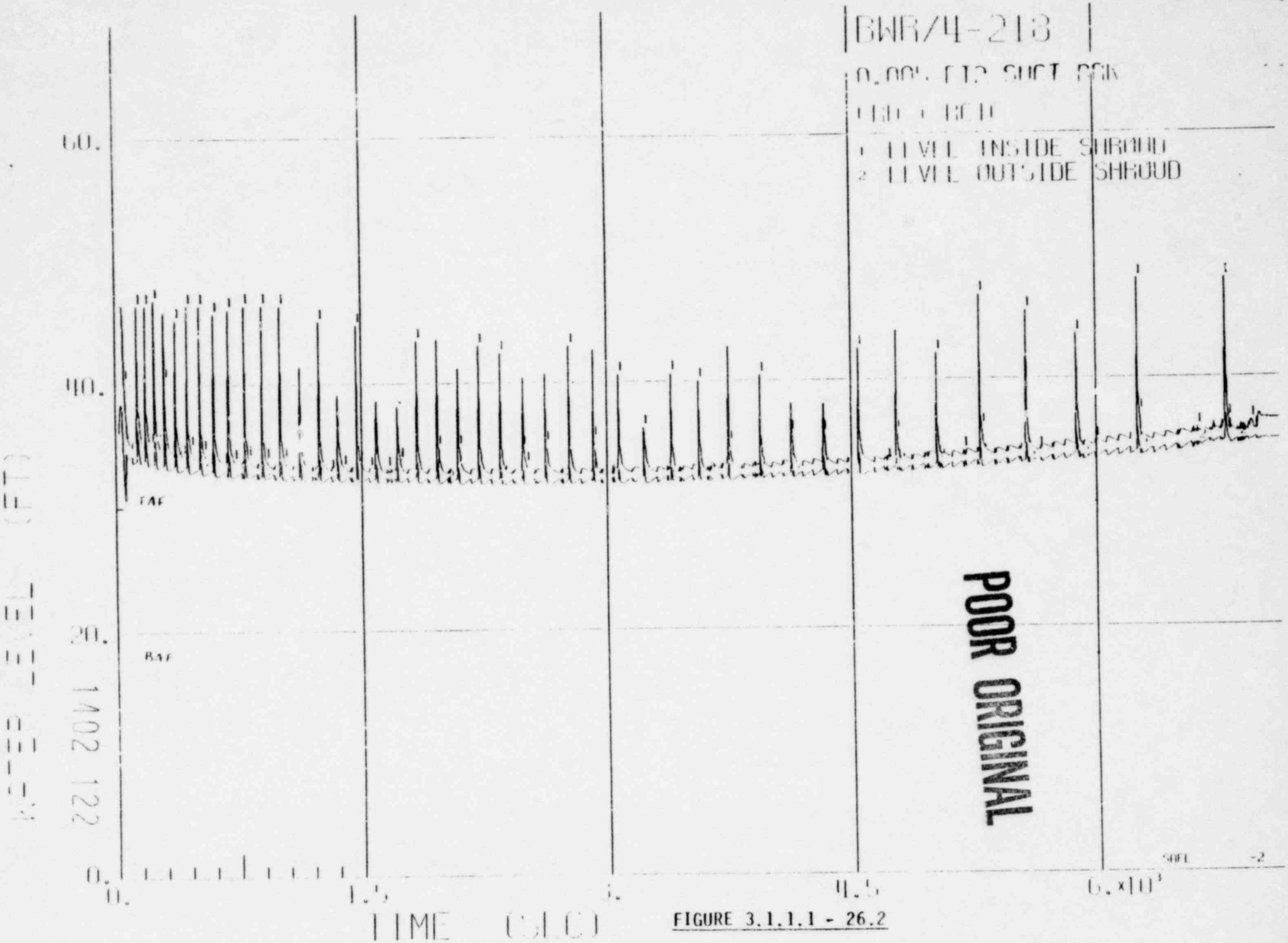


FIGURE 3.1.1.1 - 26.2

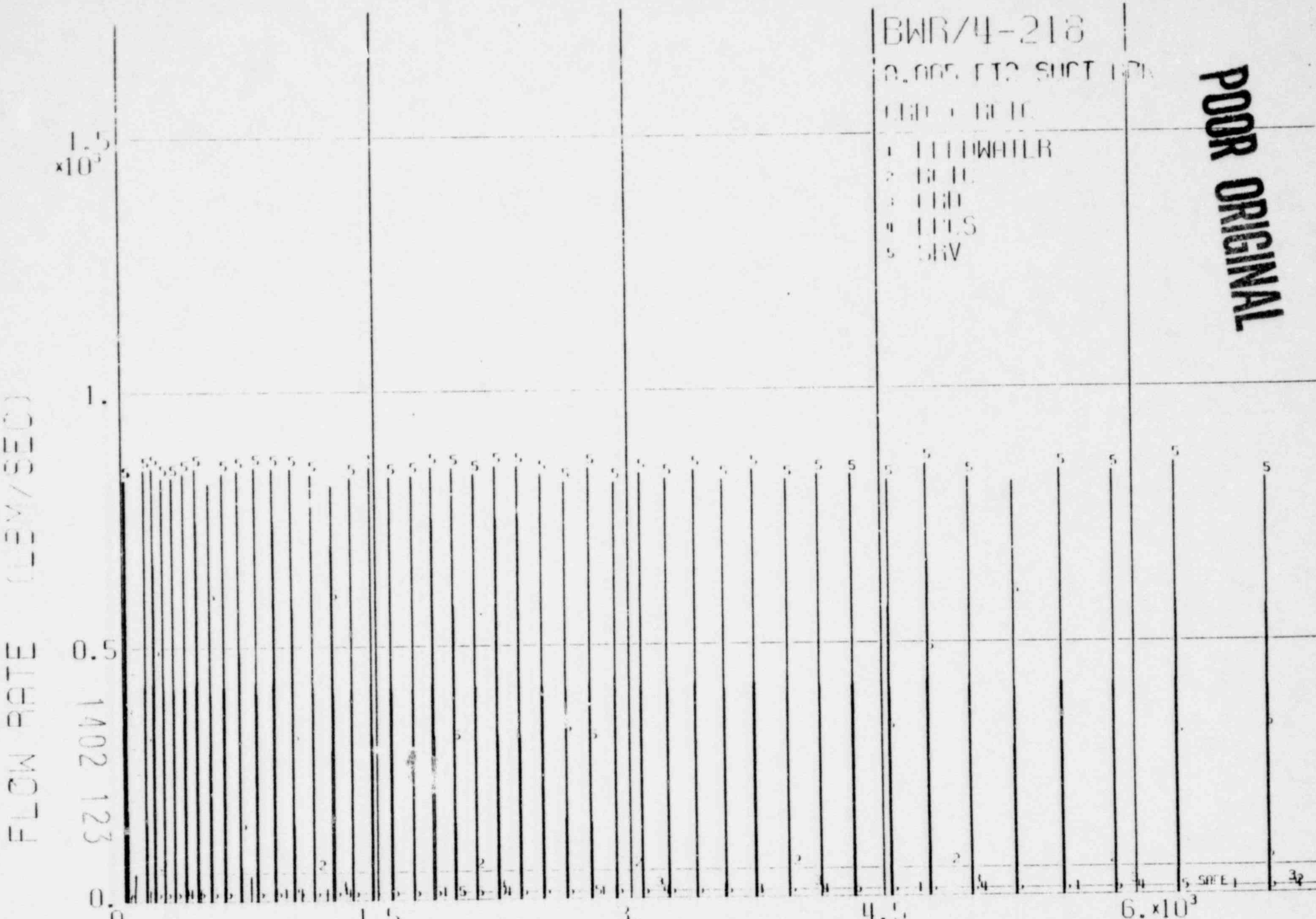


FIGURE 3.1.1.1 - 26.3

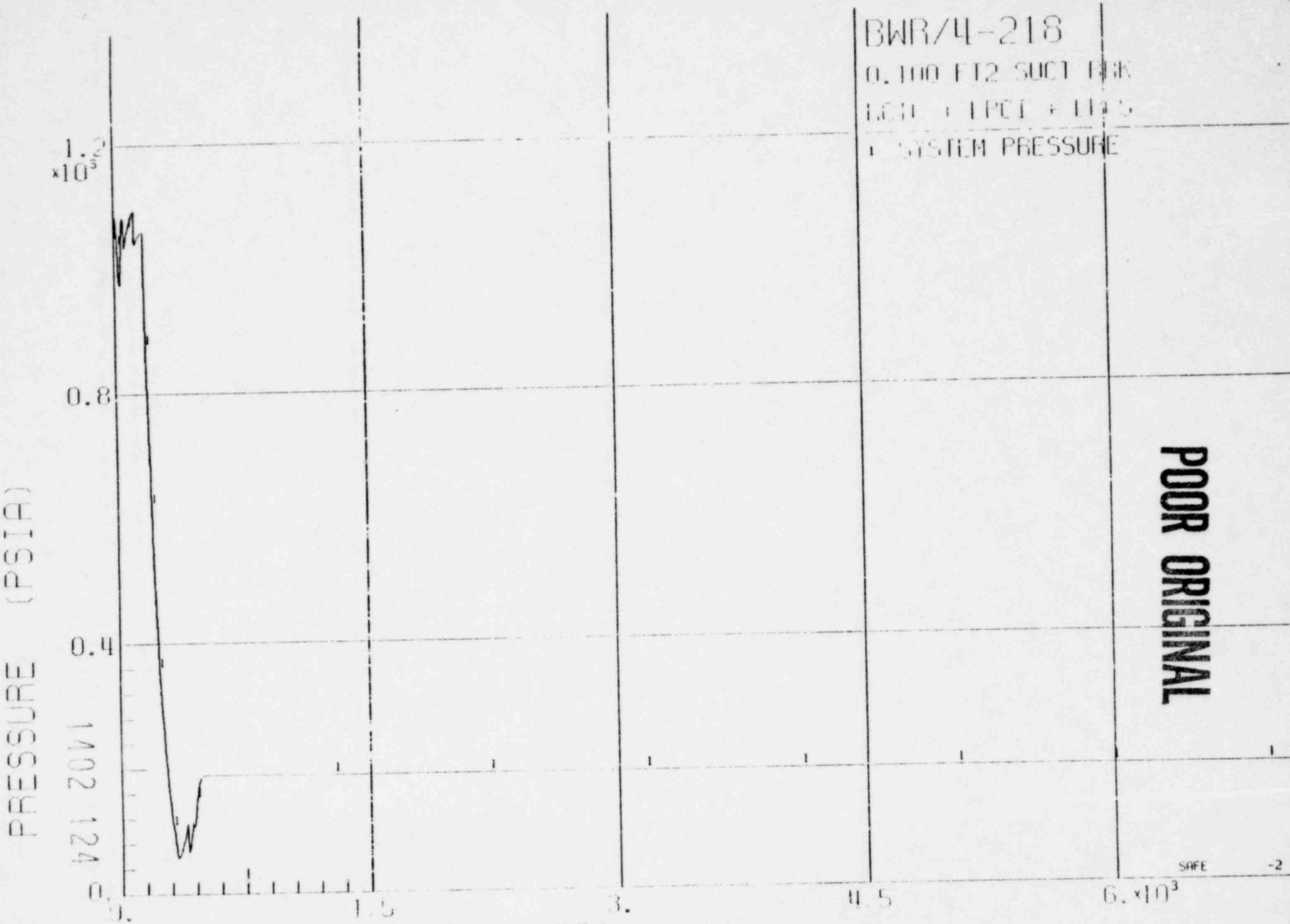


FIGURE 3.1.1.1 - 27.1

POOR ORIGINAL

1402 124

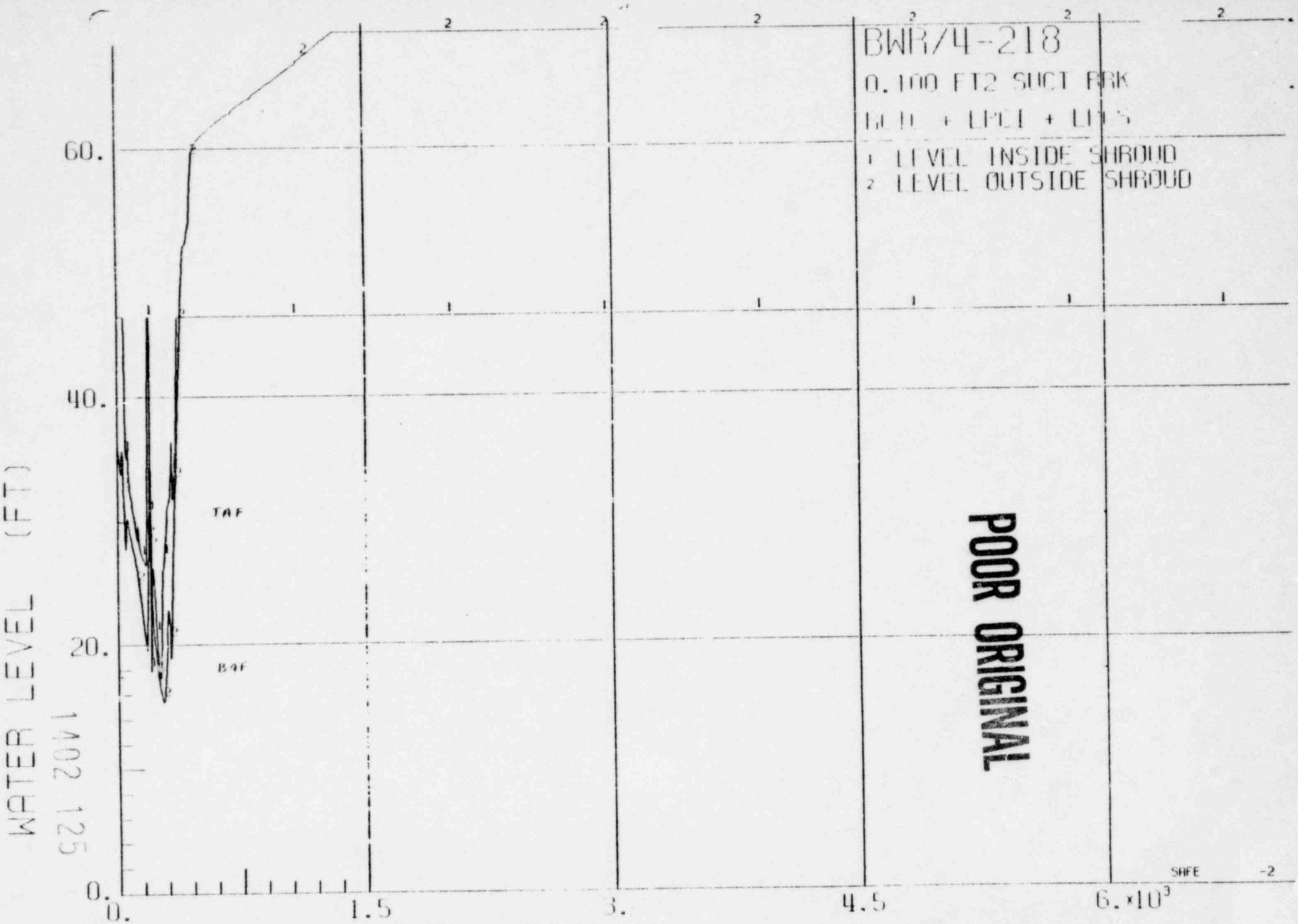
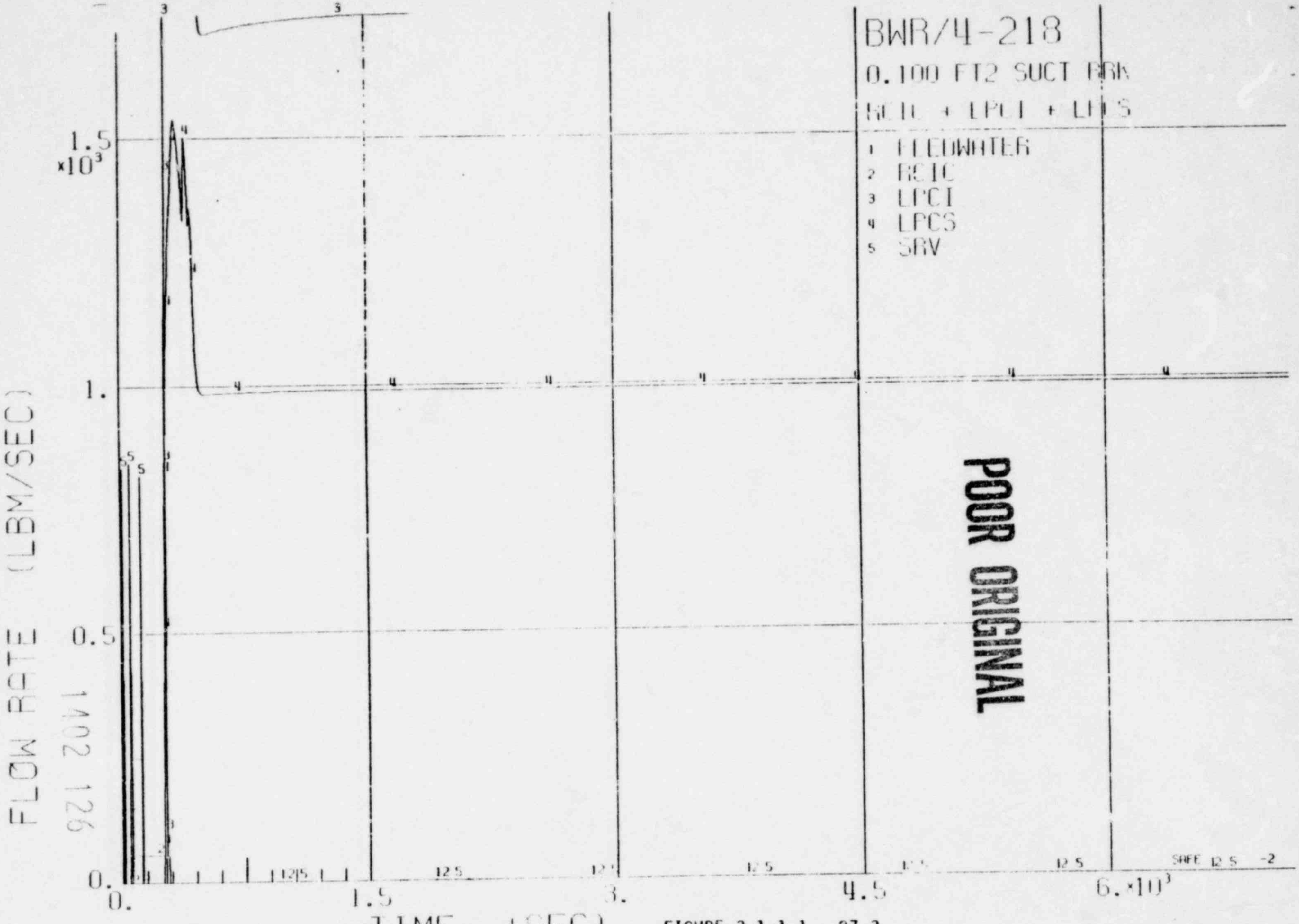


FIGURE 3.1.1.1 - 27.2

1402 125



POOR ORIGINAL

FIGURE 3.1.1.1 - 27.3

1402 126

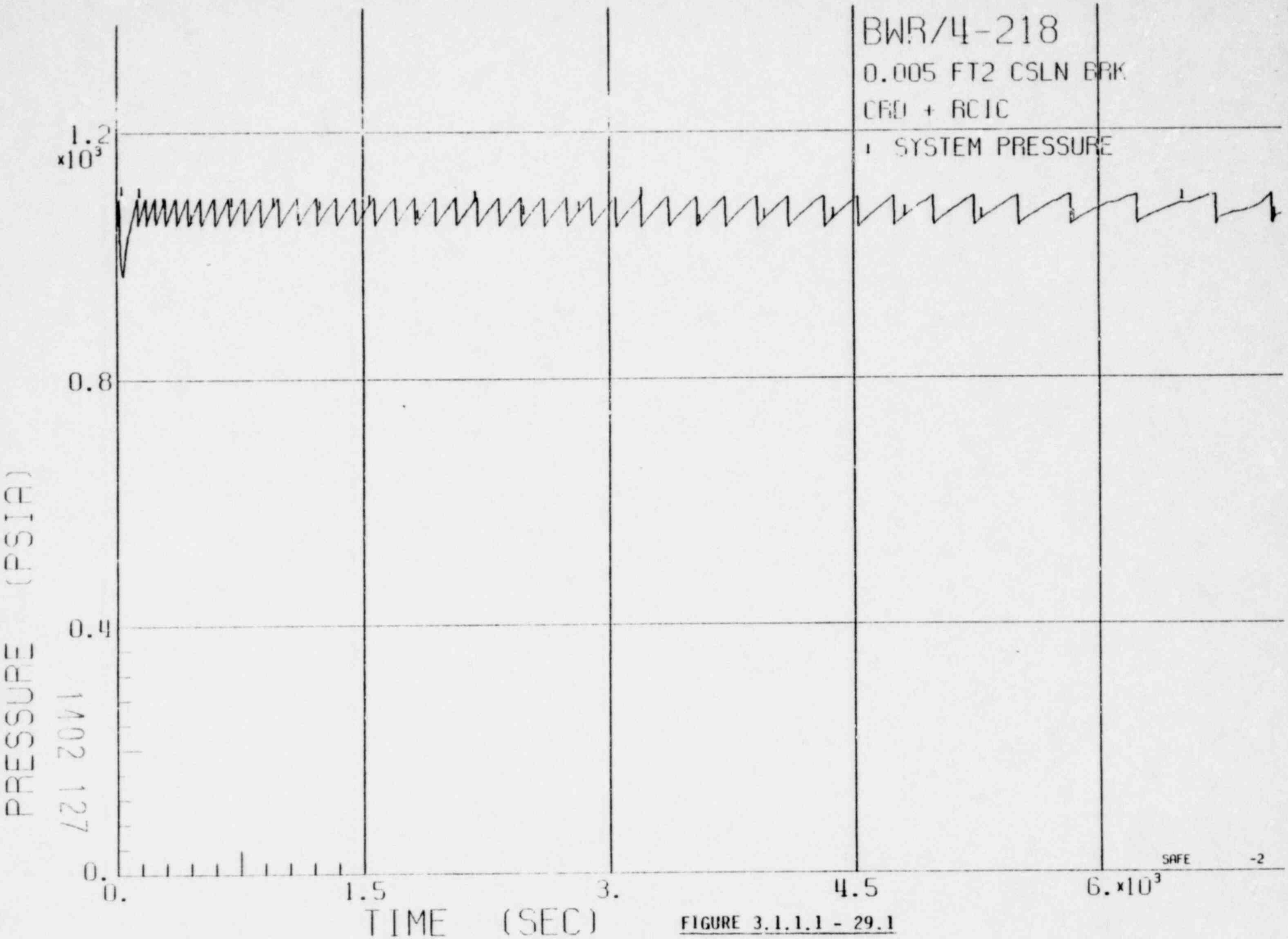


FIGURE 3.1.1.1 - 29.1

1402 127

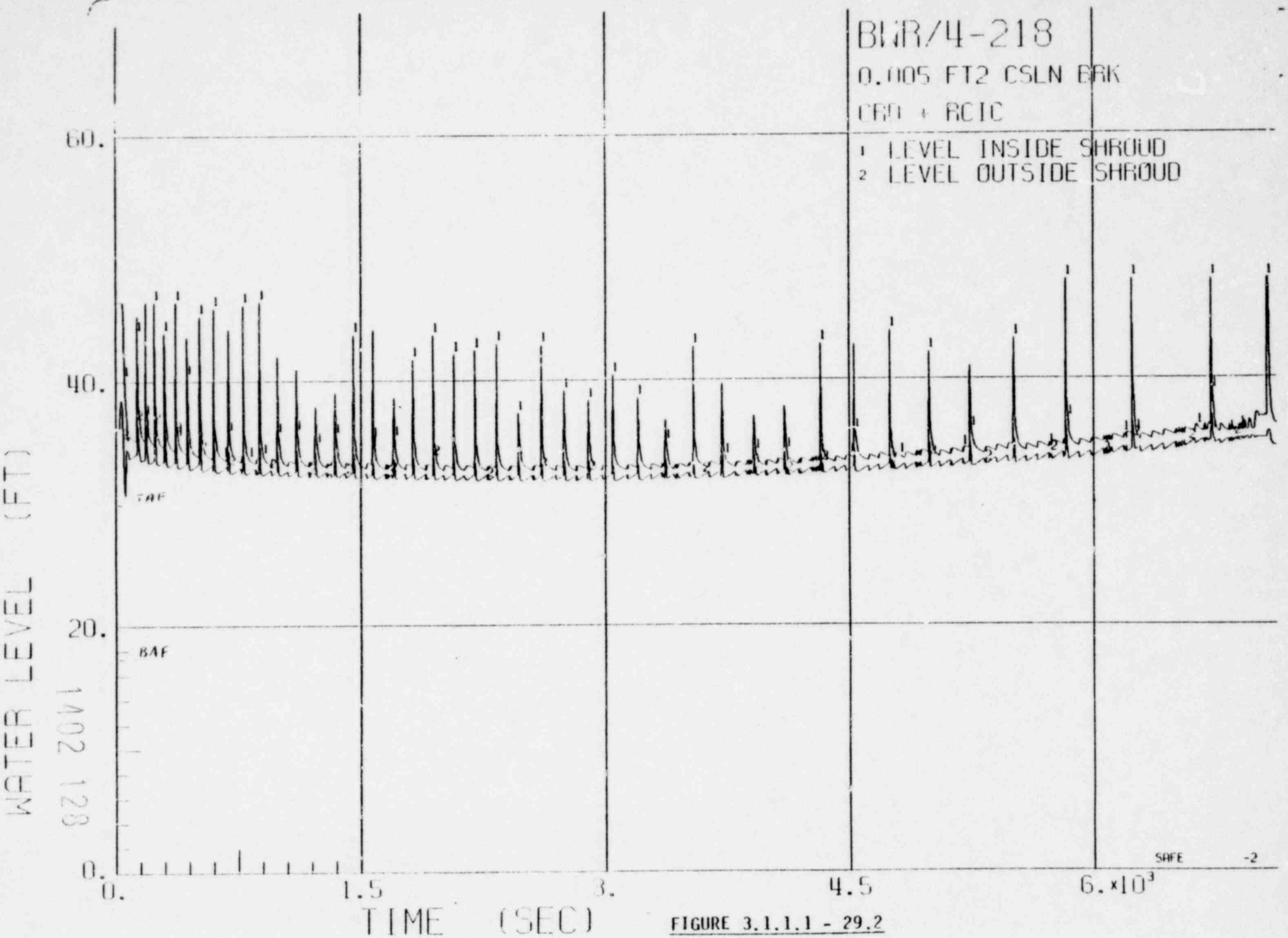


FIGURE 3.1.1.1 - 29.2

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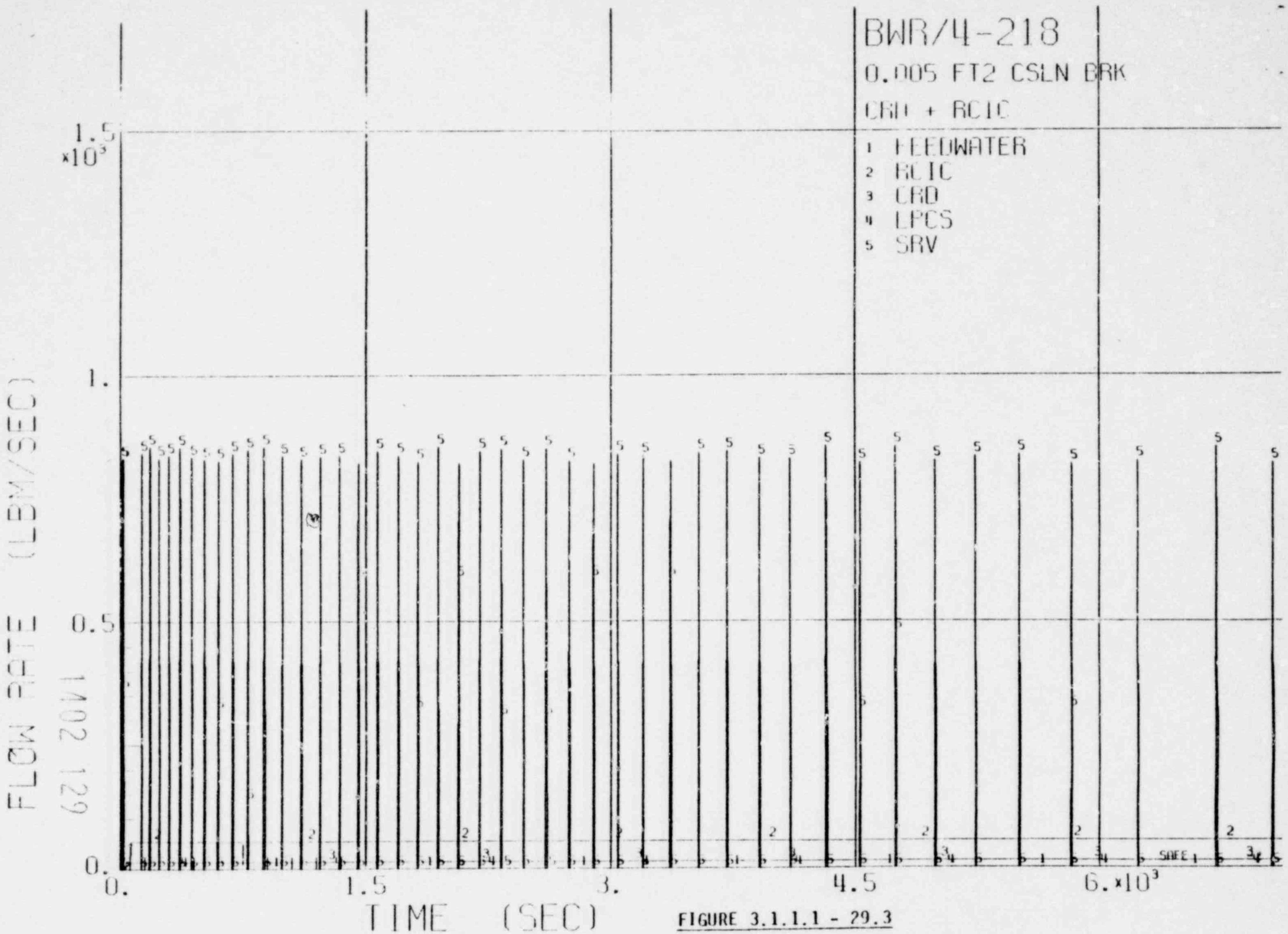


FIGURE 3.1.1.1 - 29.3

1402 129

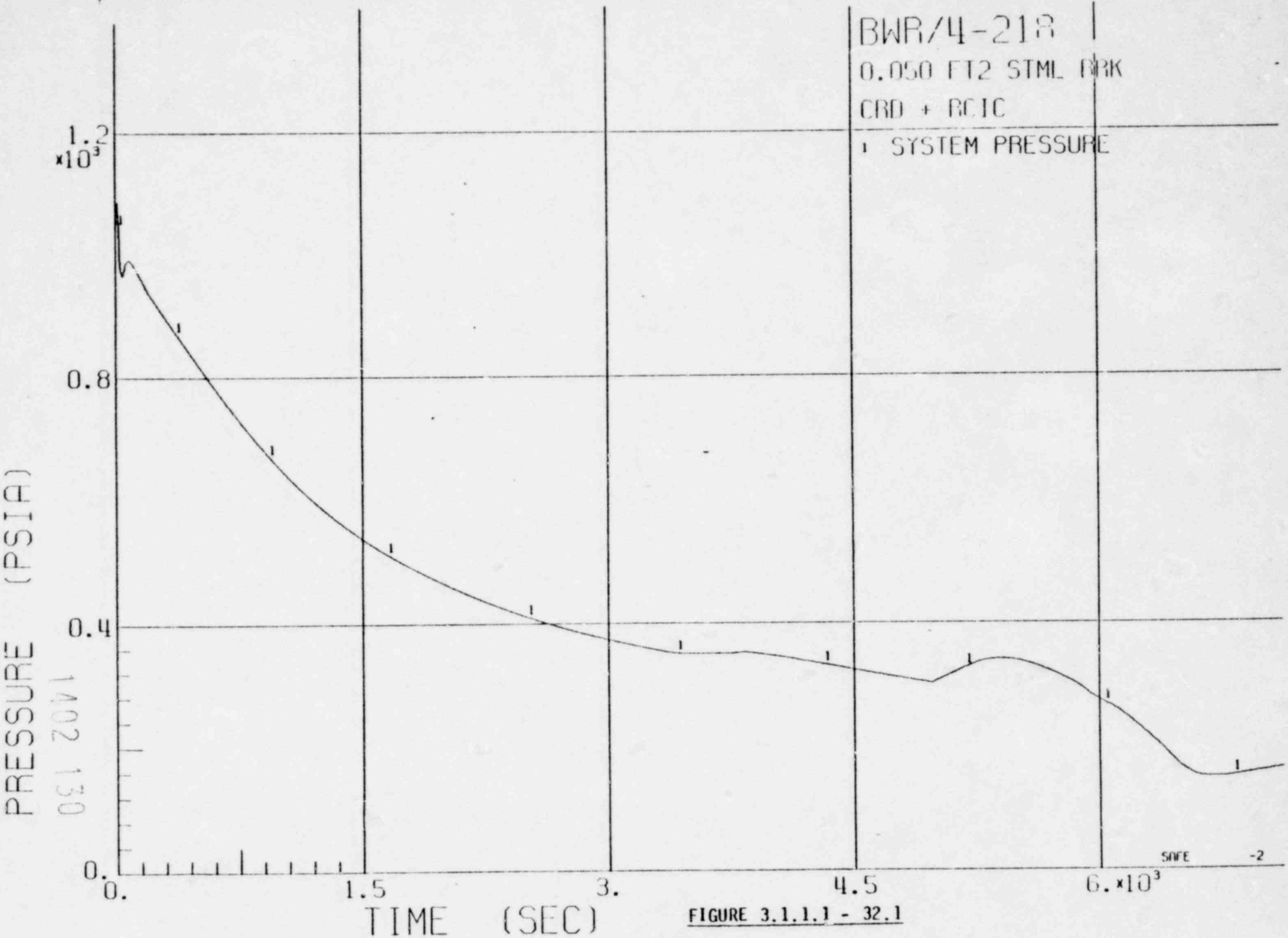


FIGURE 3.1.1.1 - 32.1

1402 130

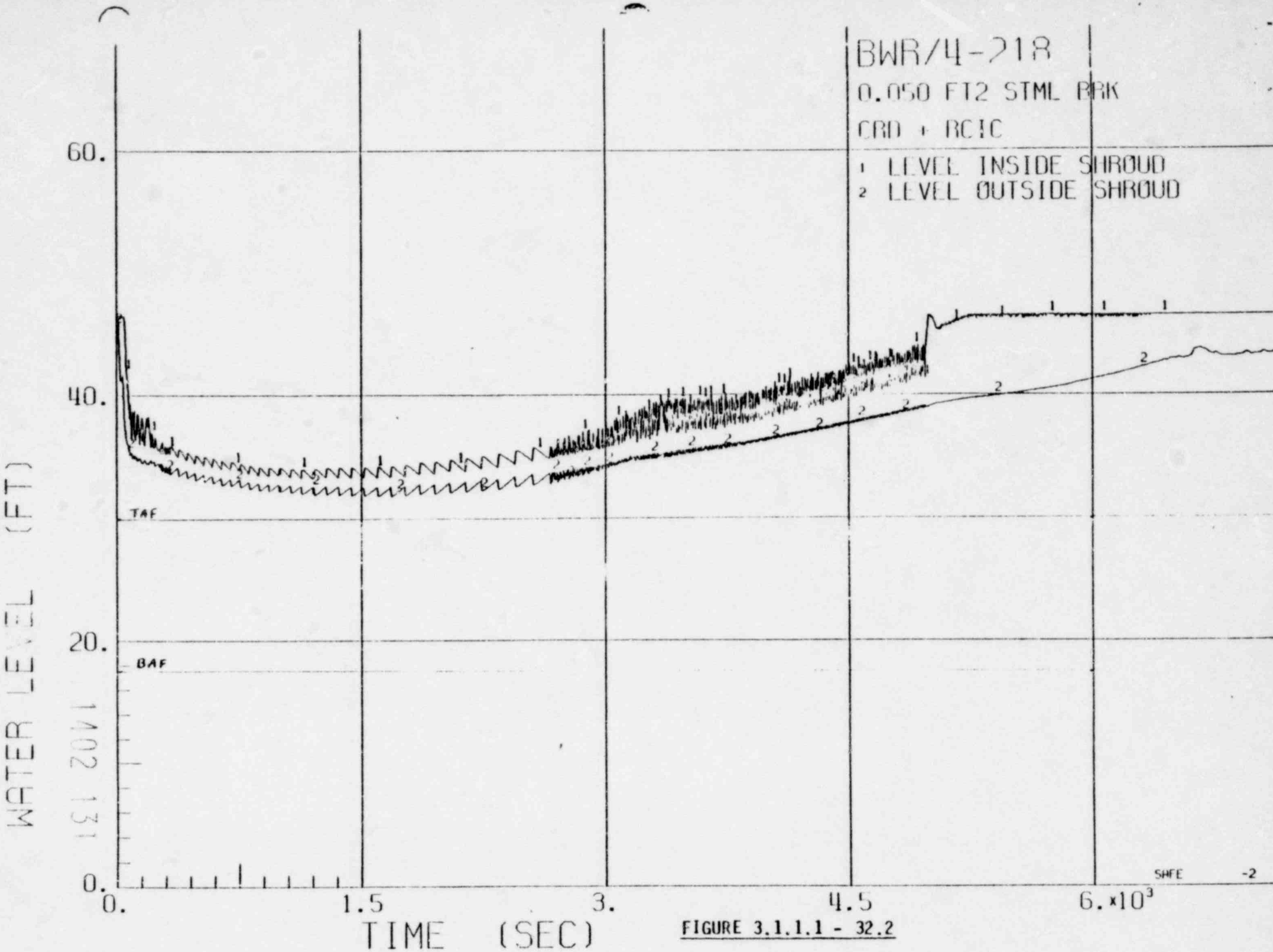


FIGURE 3.1.1.1 - 32.2

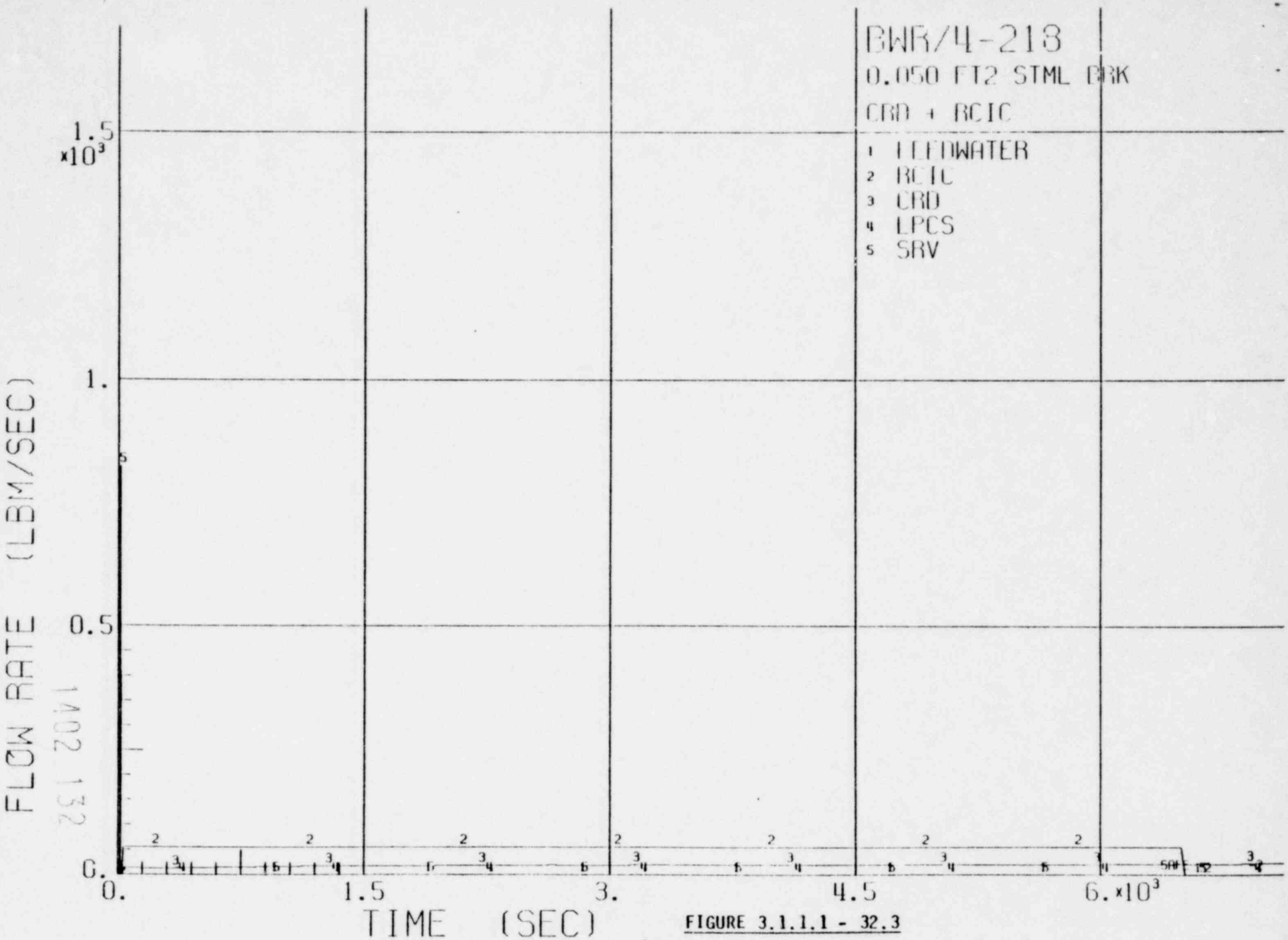


FIGURE 3.1.1.1 - 32.3

1402 132

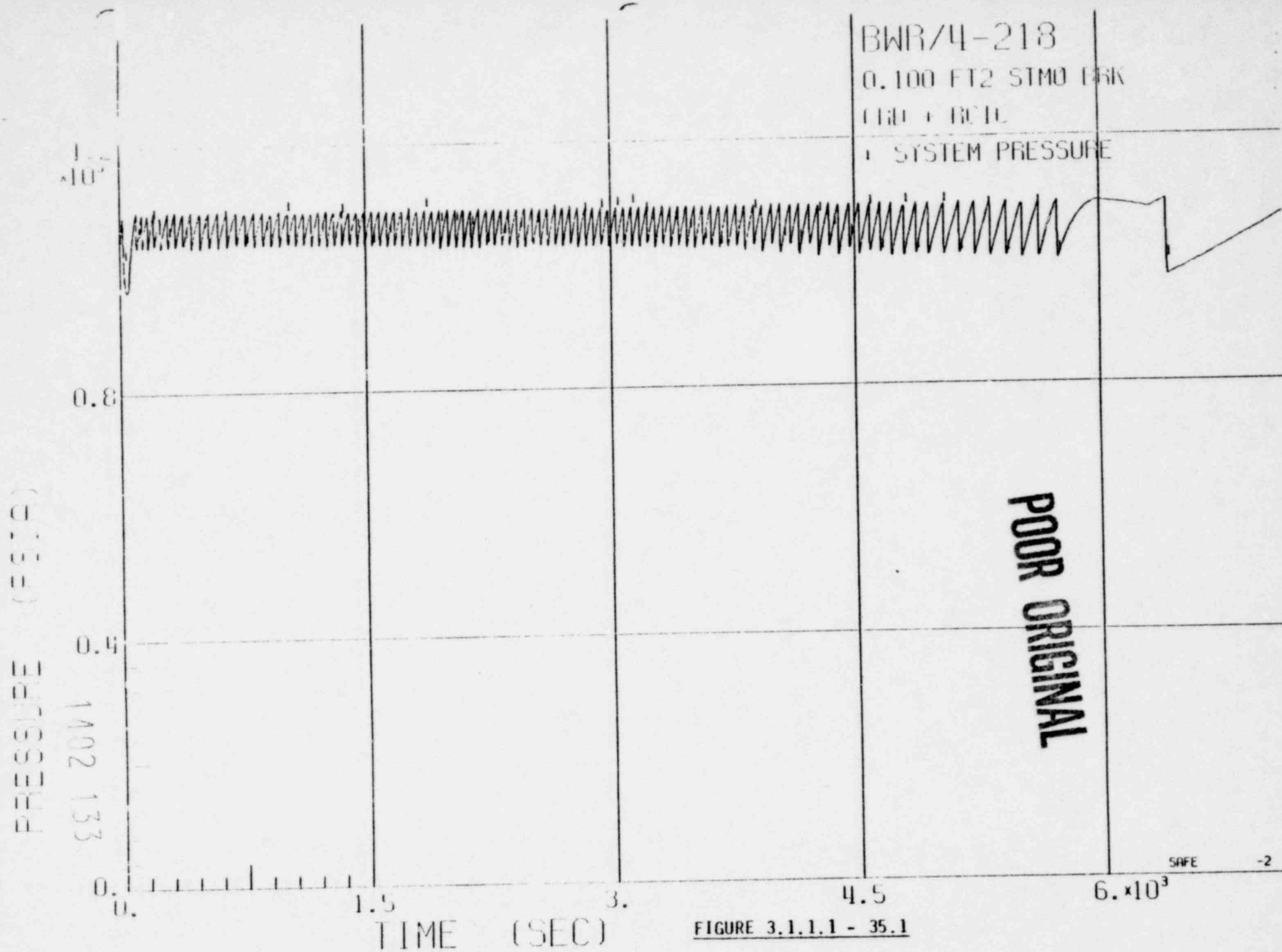


FIGURE 3.1.1.1 - 35.1

1402 133

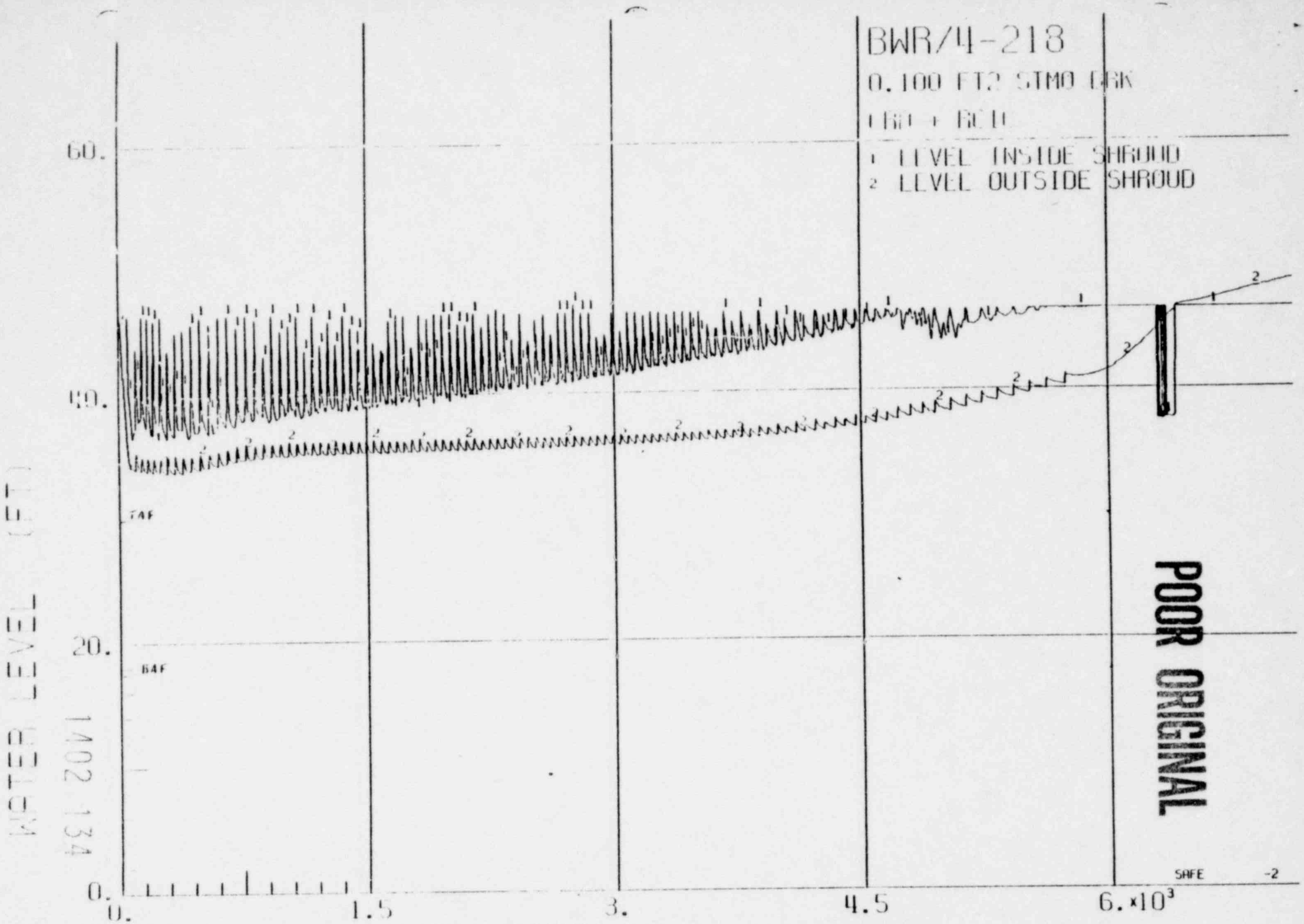


FIGURE 3.1.1.1 - 35.2

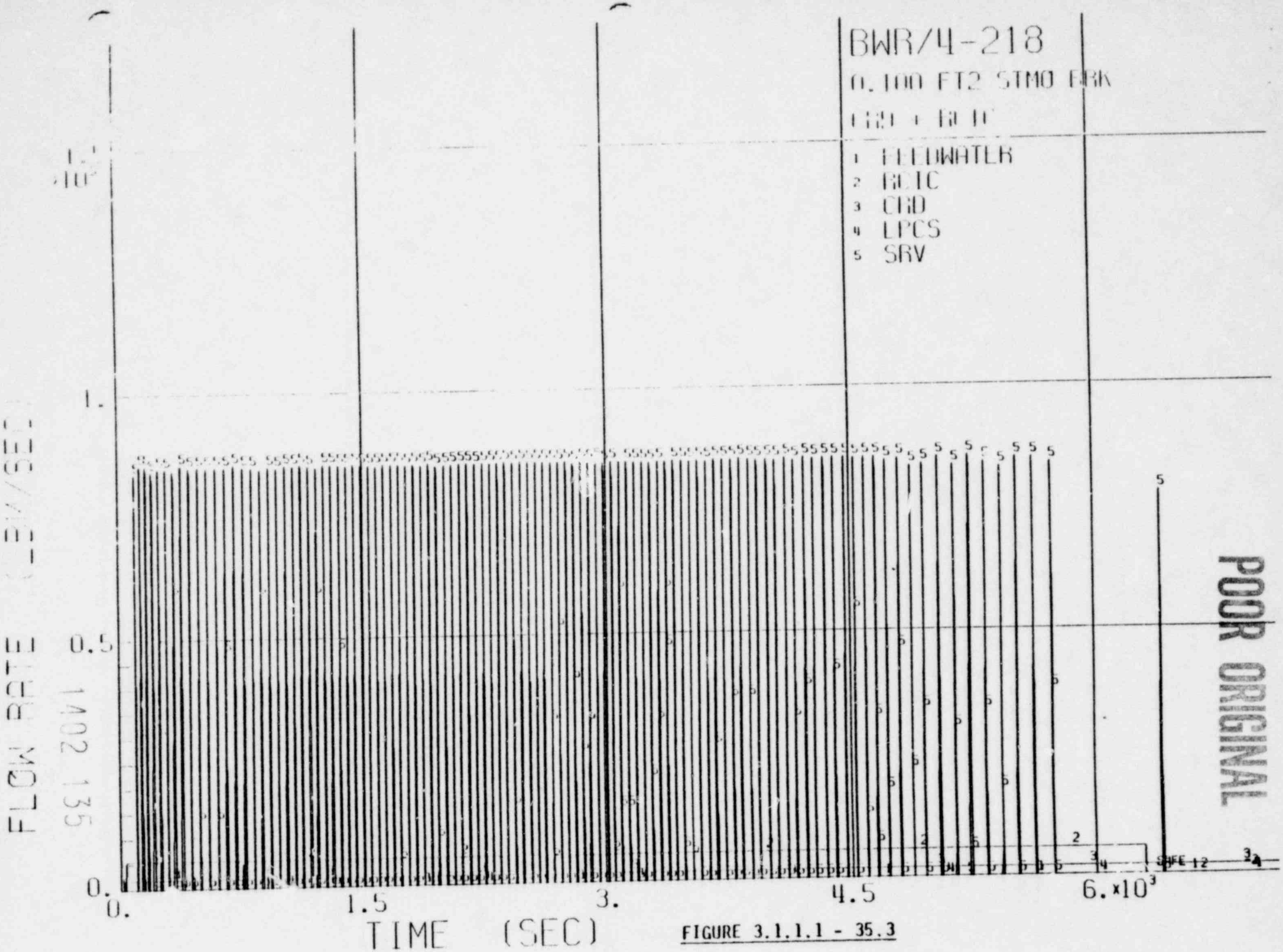


FIGURE 3.1.1.1 - 35.3

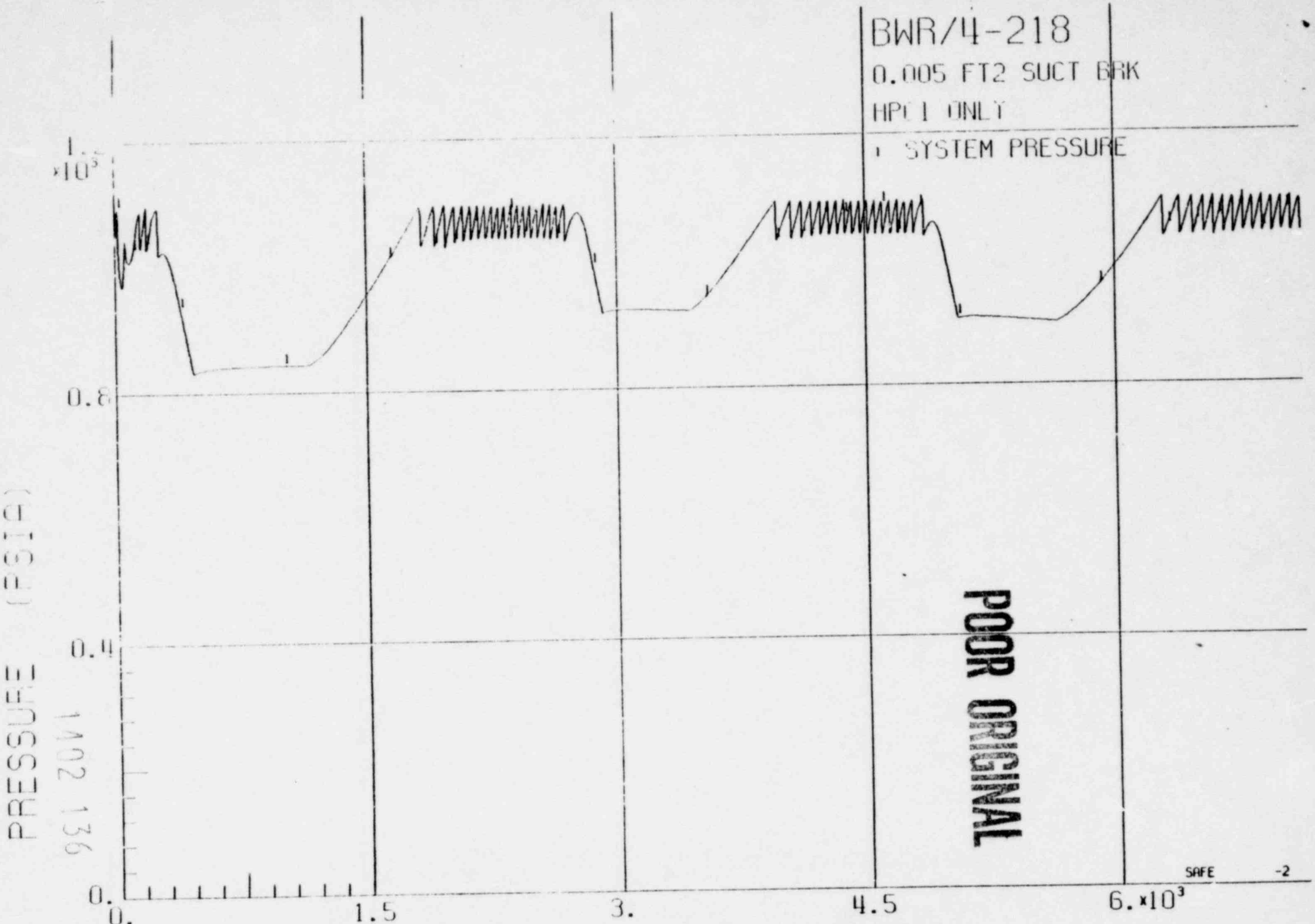


FIGURE 3.1.1.1 - 36.1

1402 136

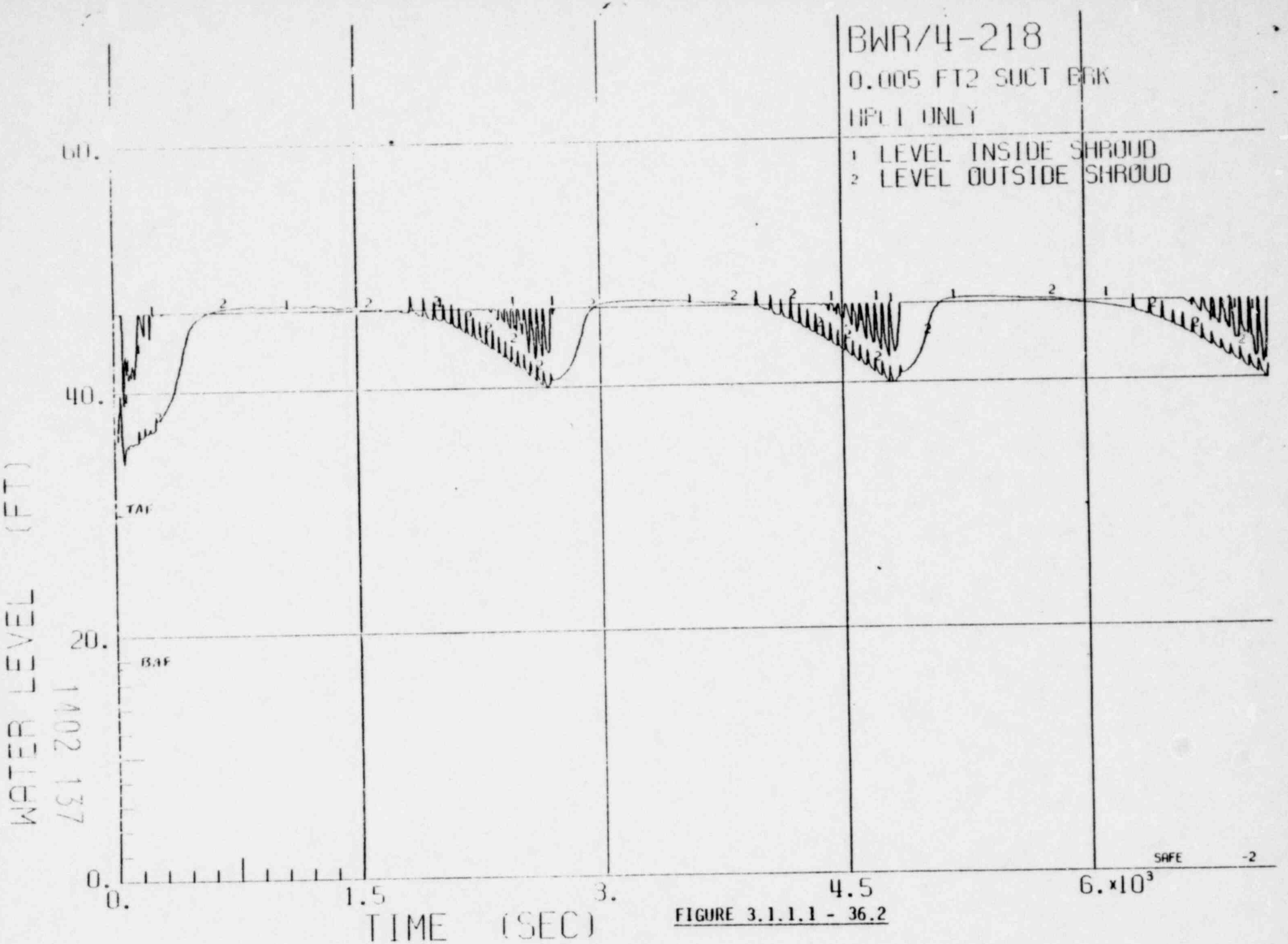


FIGURE 3.1.1.1 - 36.2

1402 137

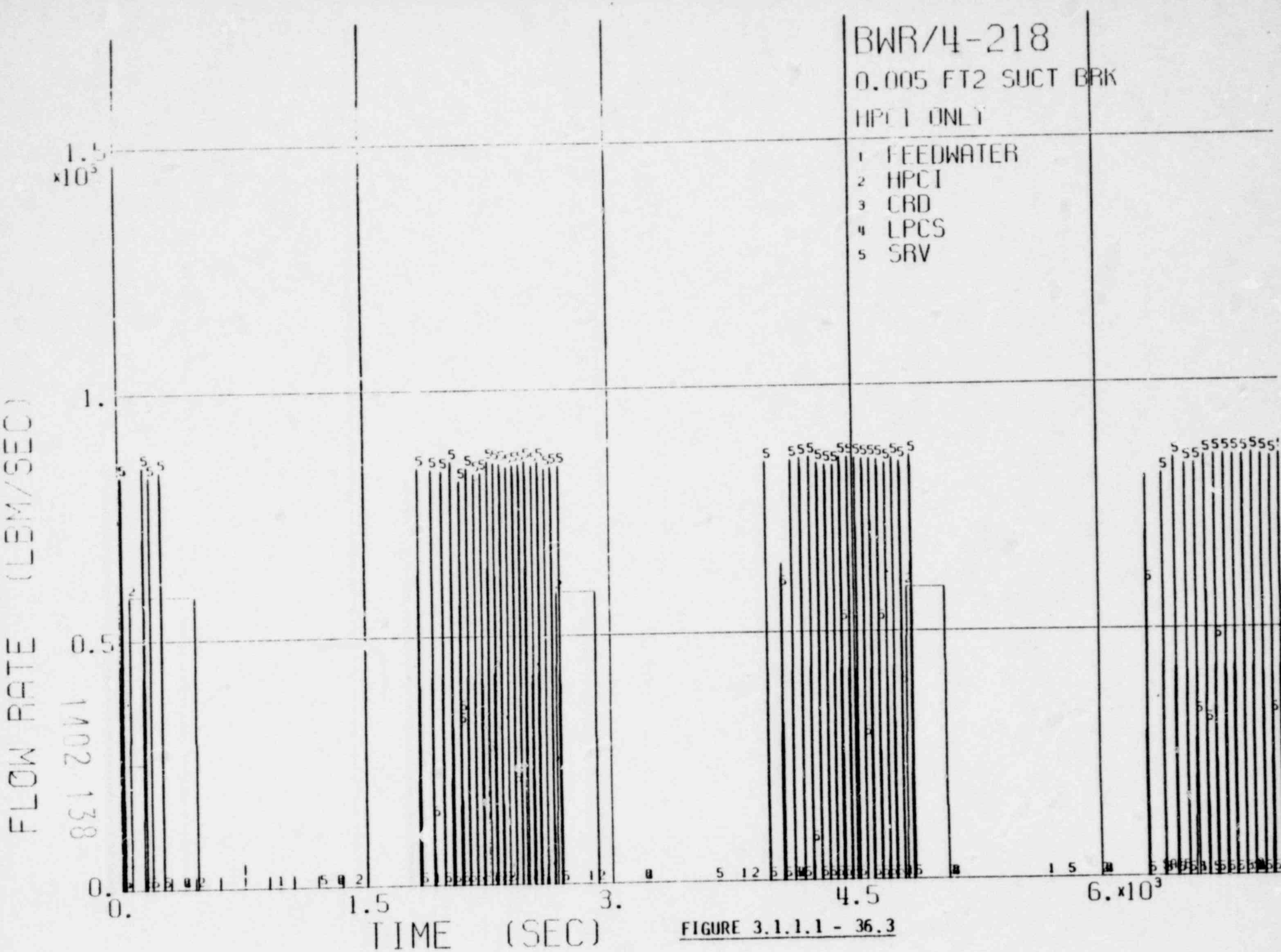
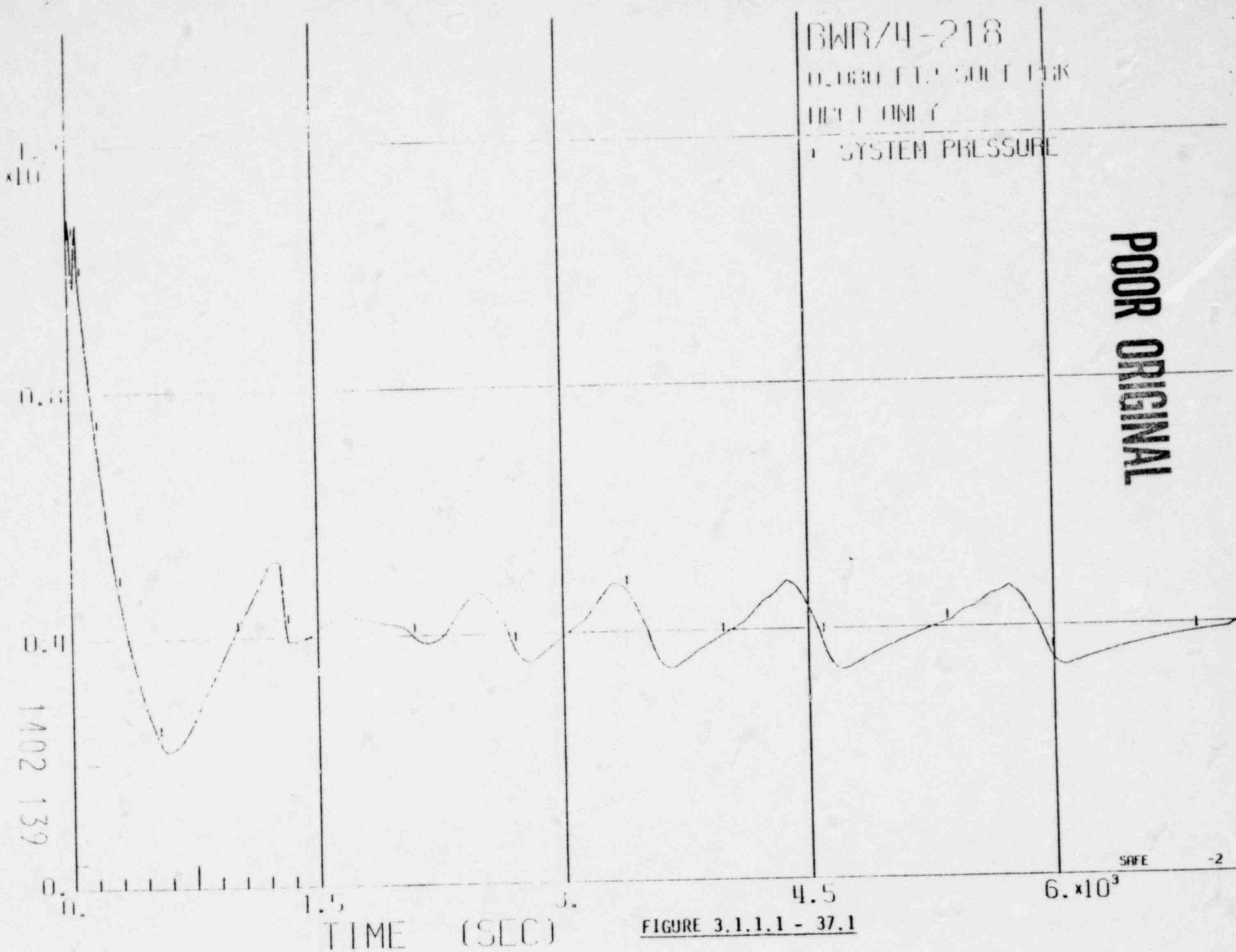


FIGURE 3.1.1.1 - 36.3

1402 138



POOR ORIGINAL

FIGURE 3.1.1.1 - 37.1

1402 139

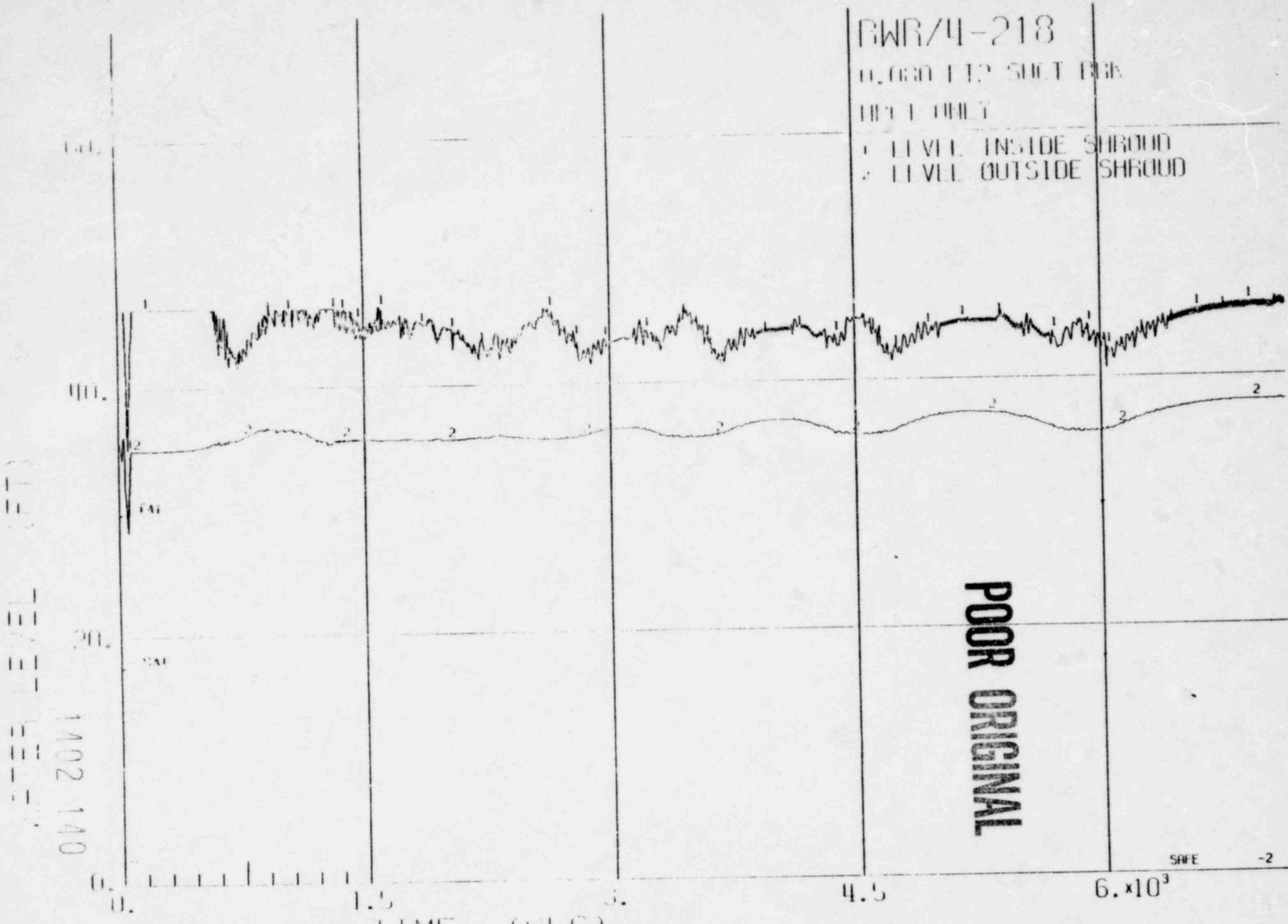


FIGURE 3.1.1.1 - 37.2

1402 140

POOR ORIGINAL

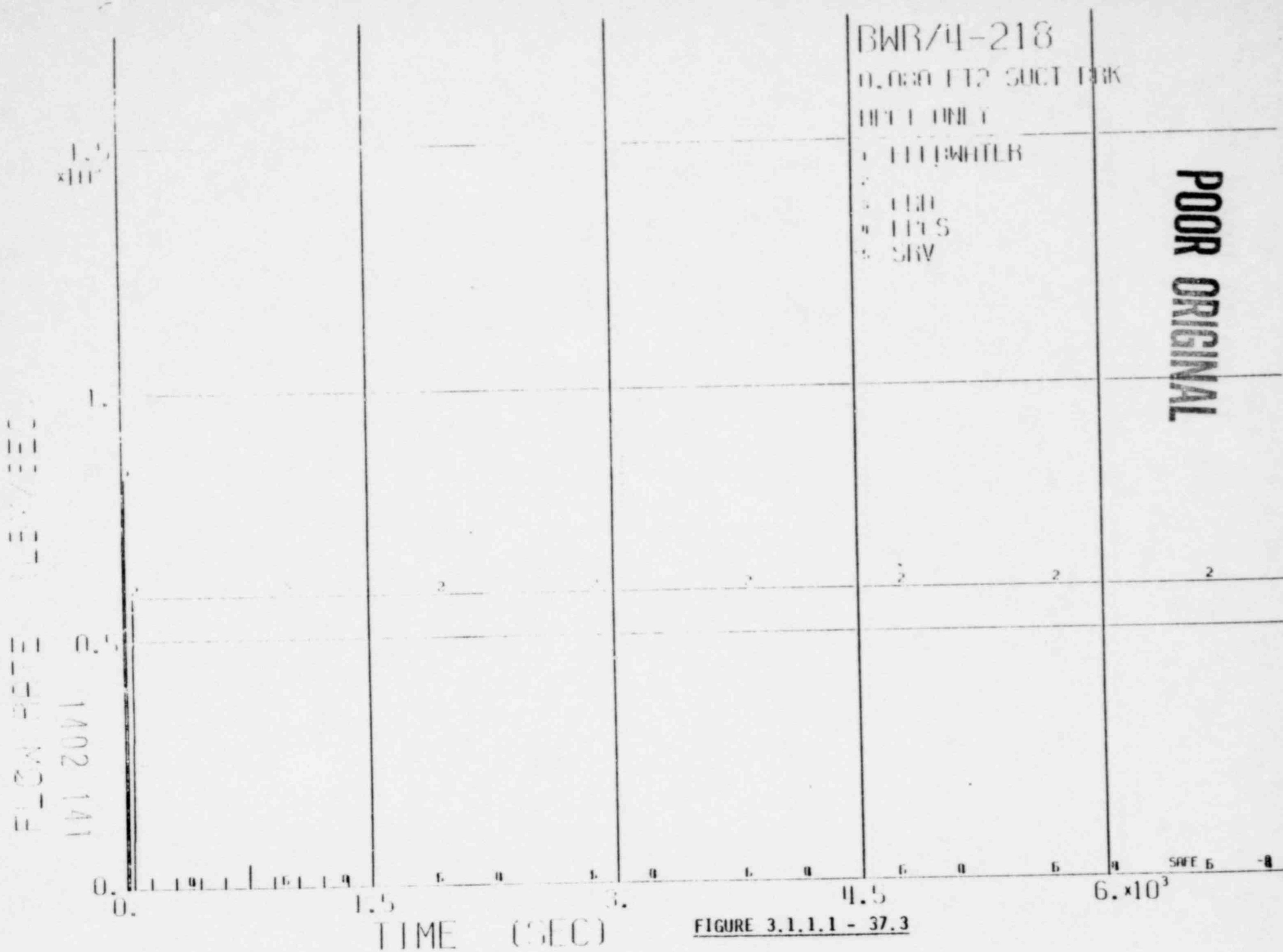


FIGURE 3.1.1.1 - 37.3

1402 141

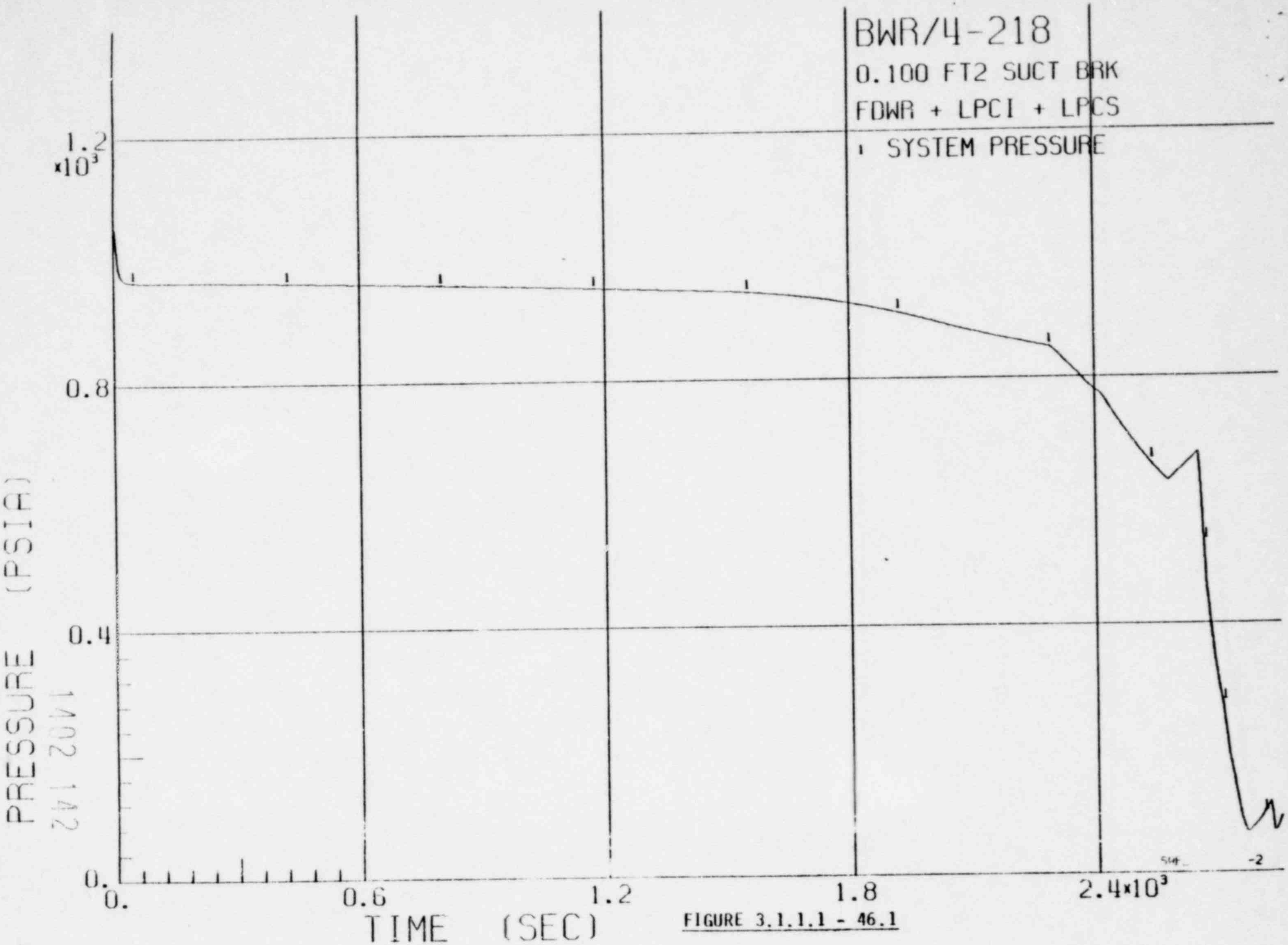


FIGURE 3.1.1.1 - 46.1

1402 142

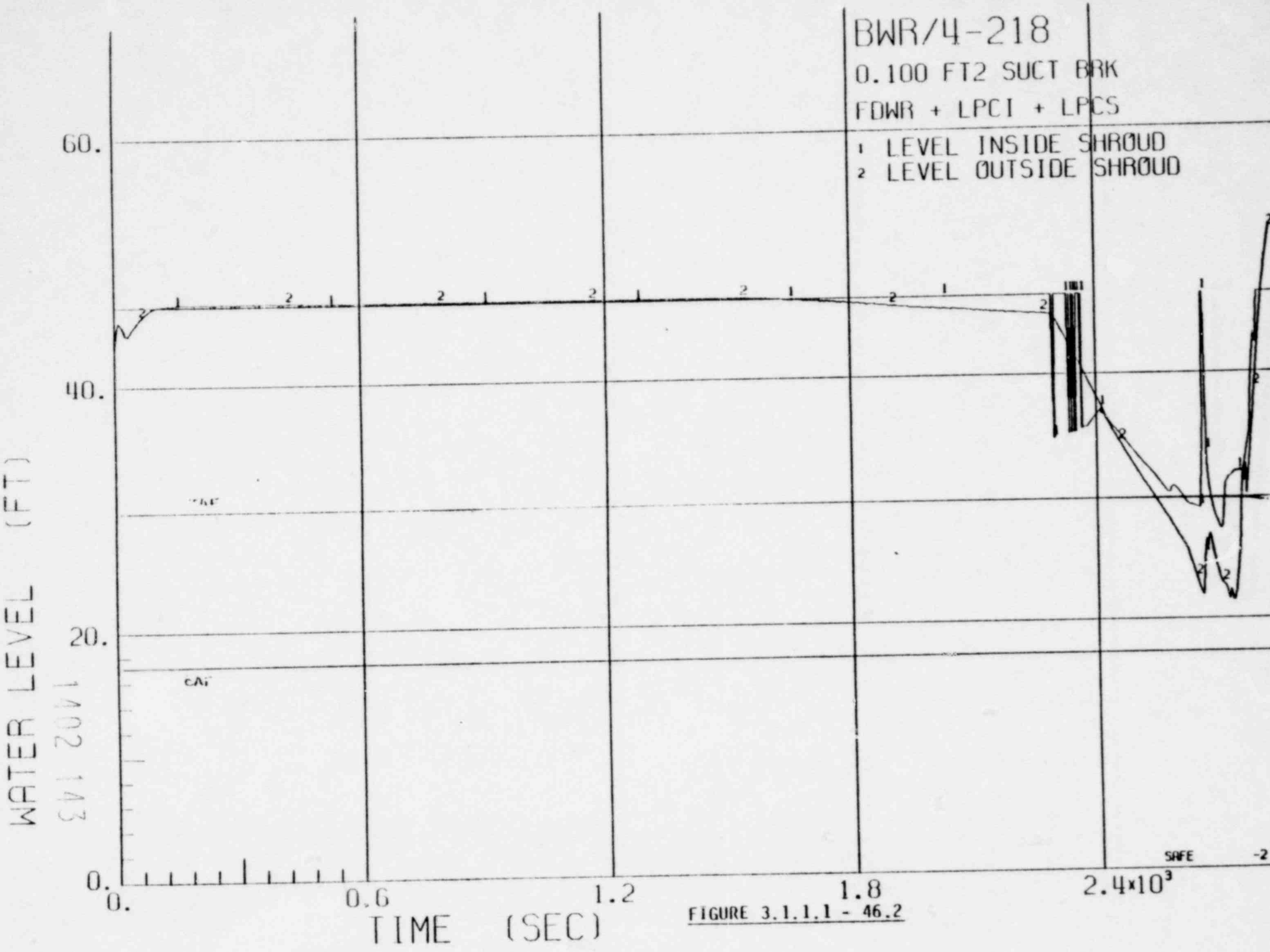


FIGURE 3.1.1.1 - 46.2

1402 143

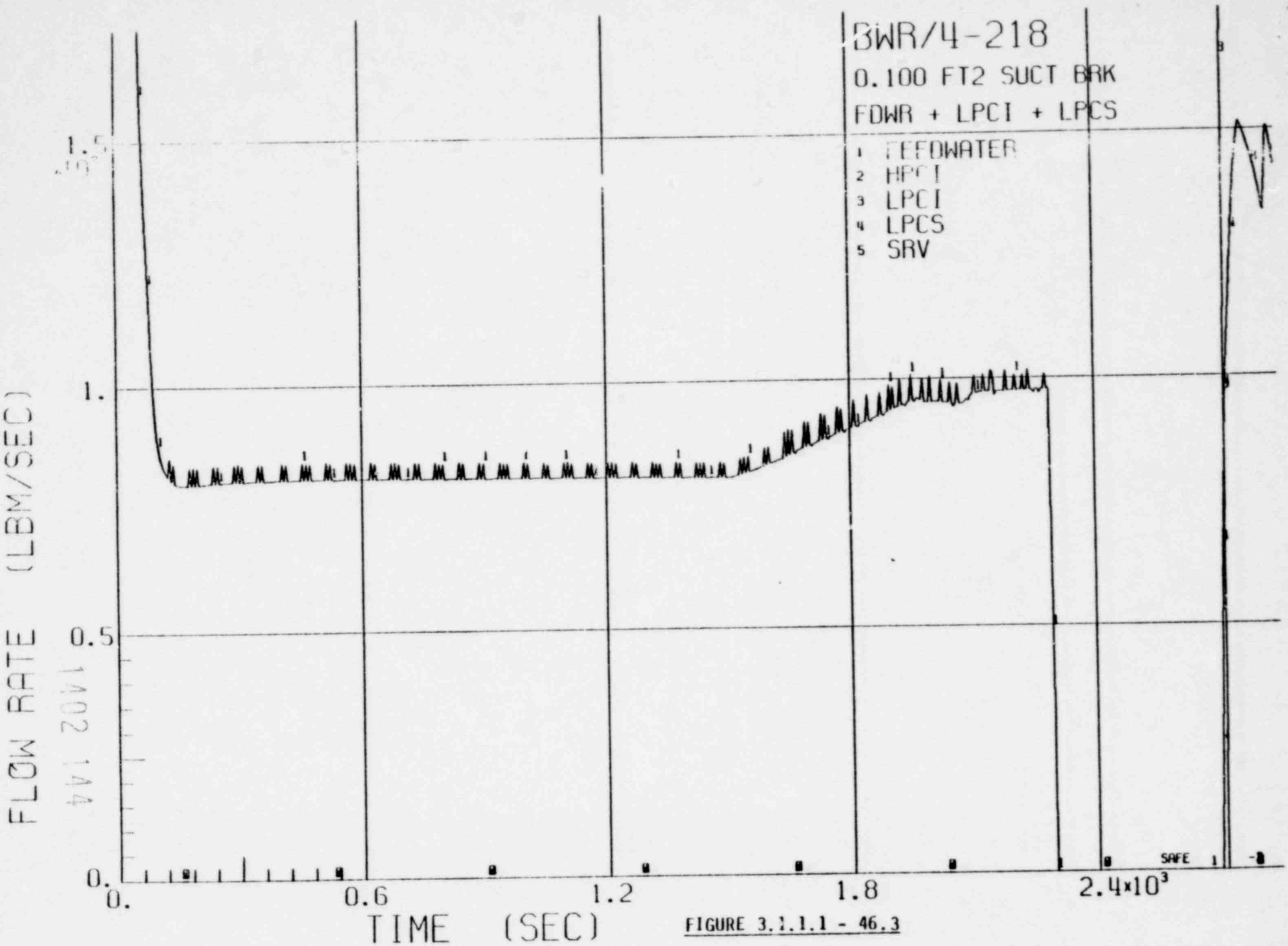


FIGURE 3.1.1.1 - 46.3

1402 144

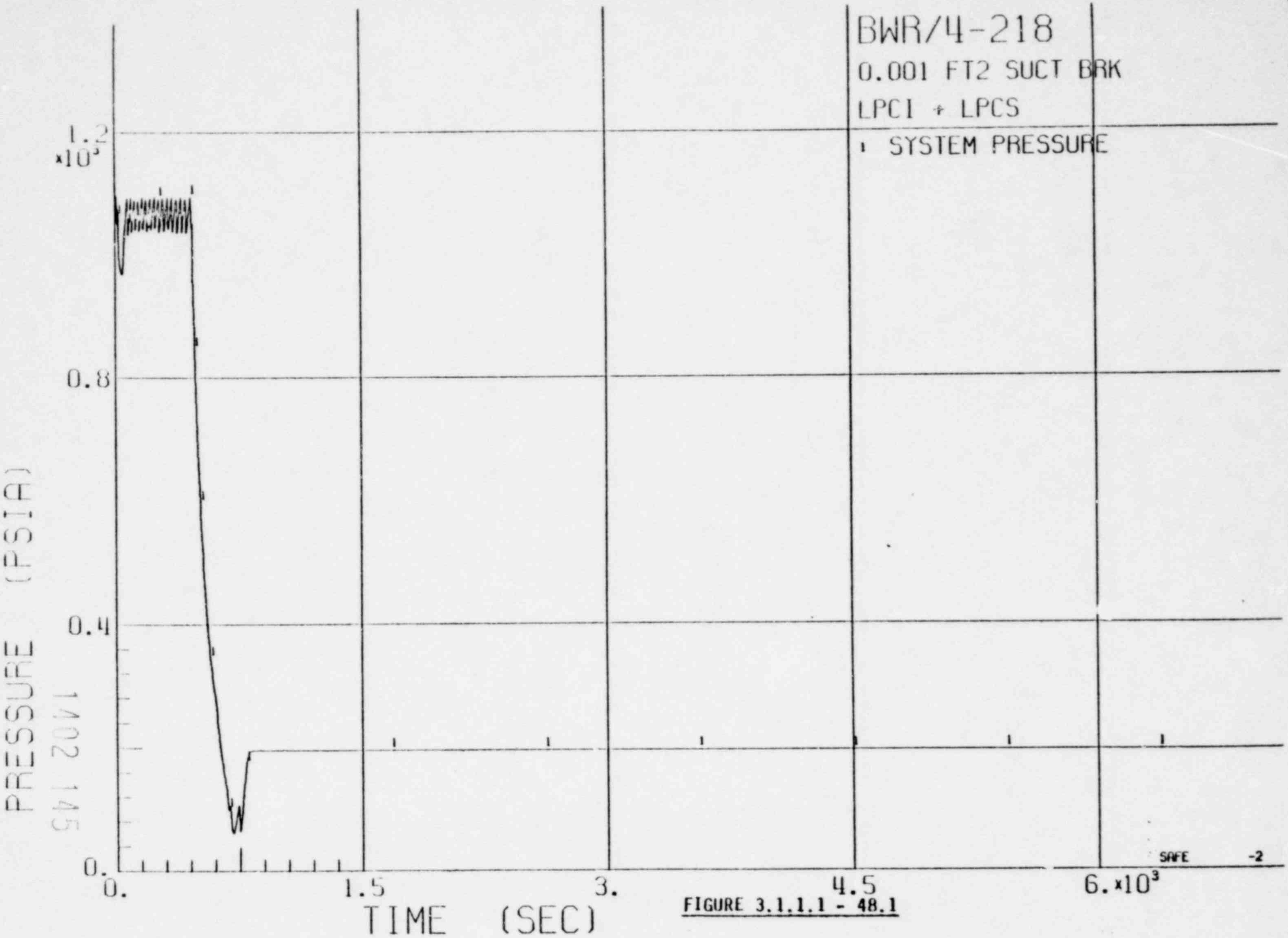


FIGURE 3.1.1.1 - 48.1

1402 145

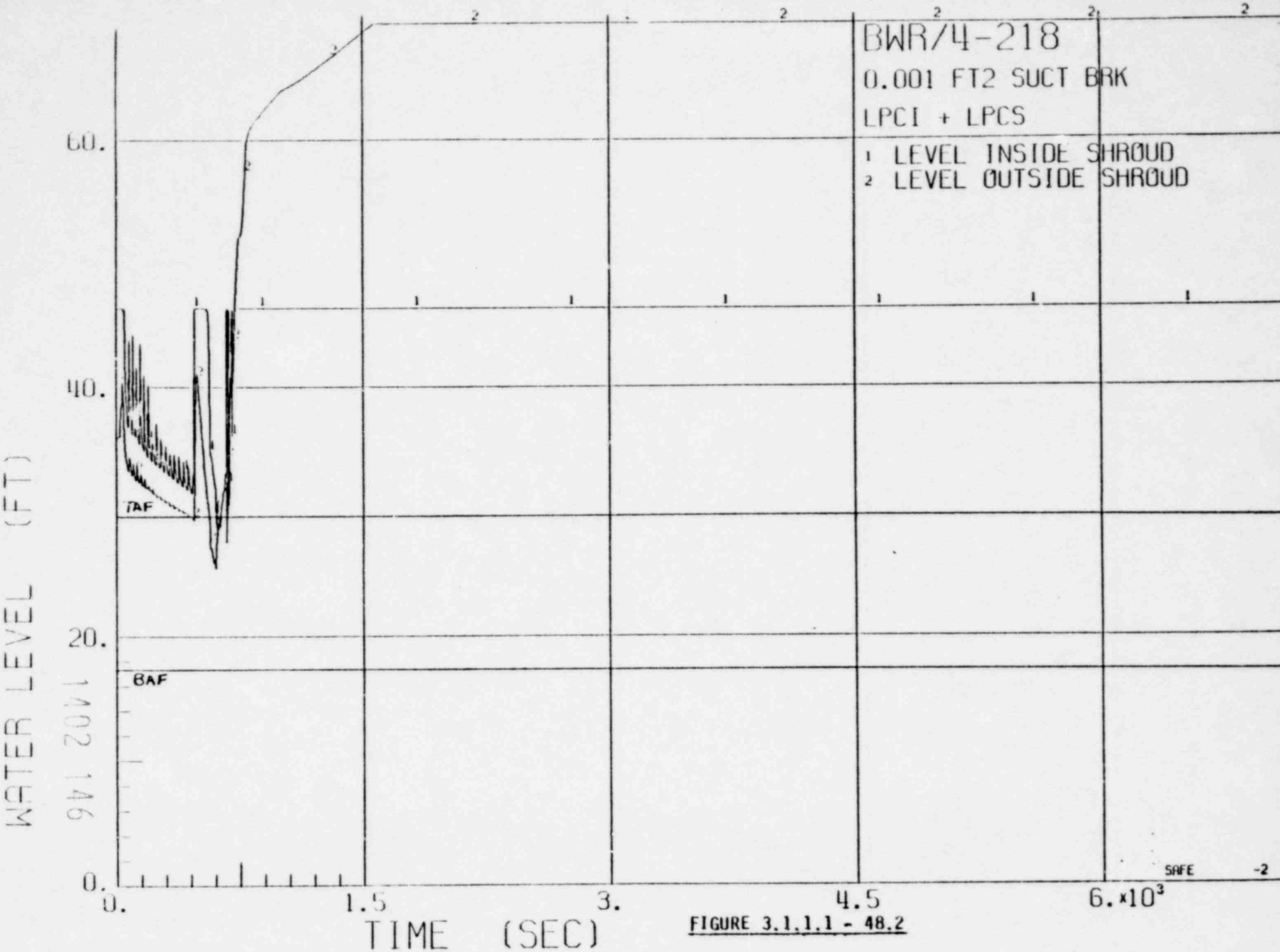


FIGURE 3.1.1.1 - 48.2

1402 146

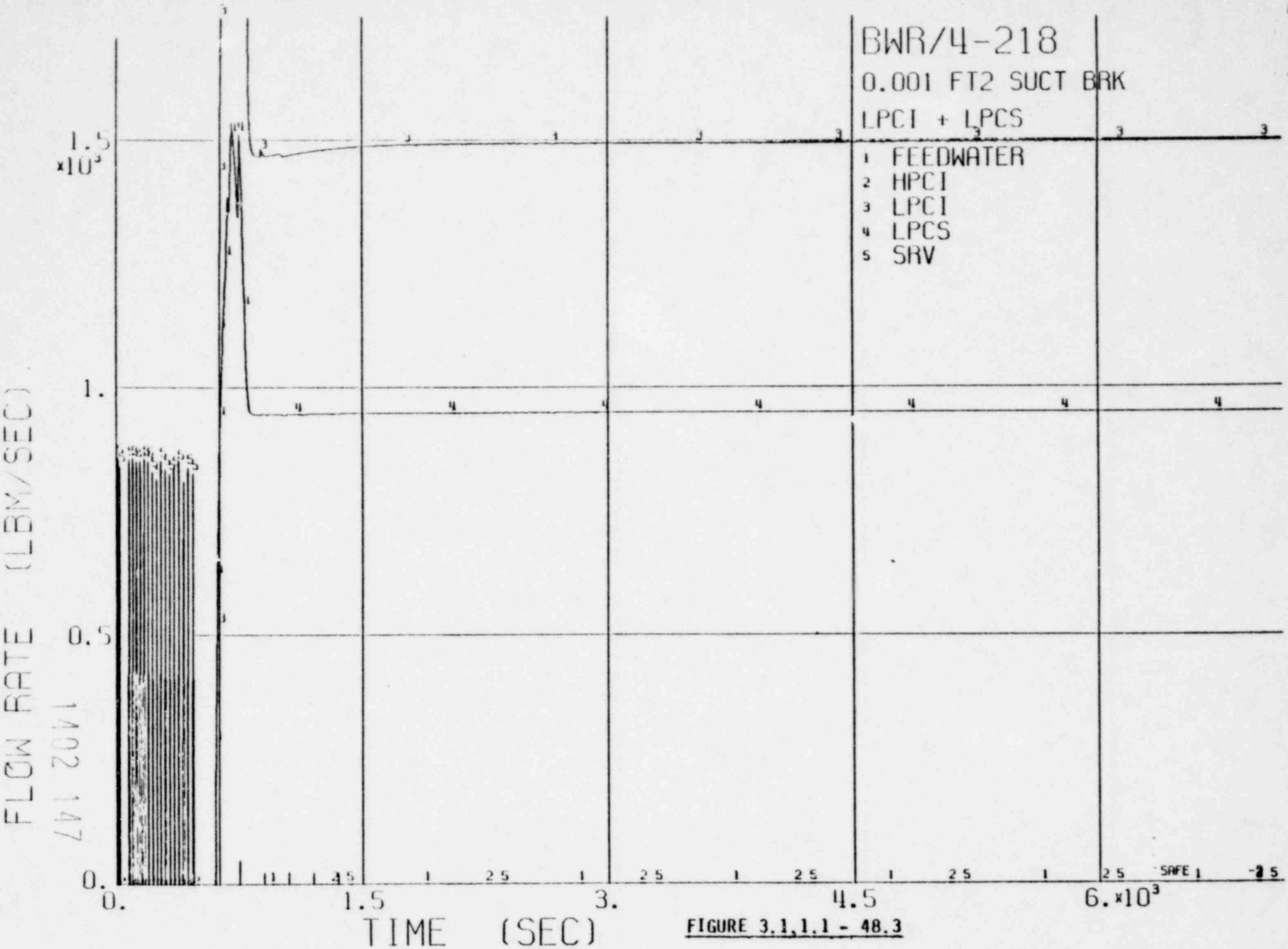


FIGURE 3.1.1.1 - 48.3

1402 147

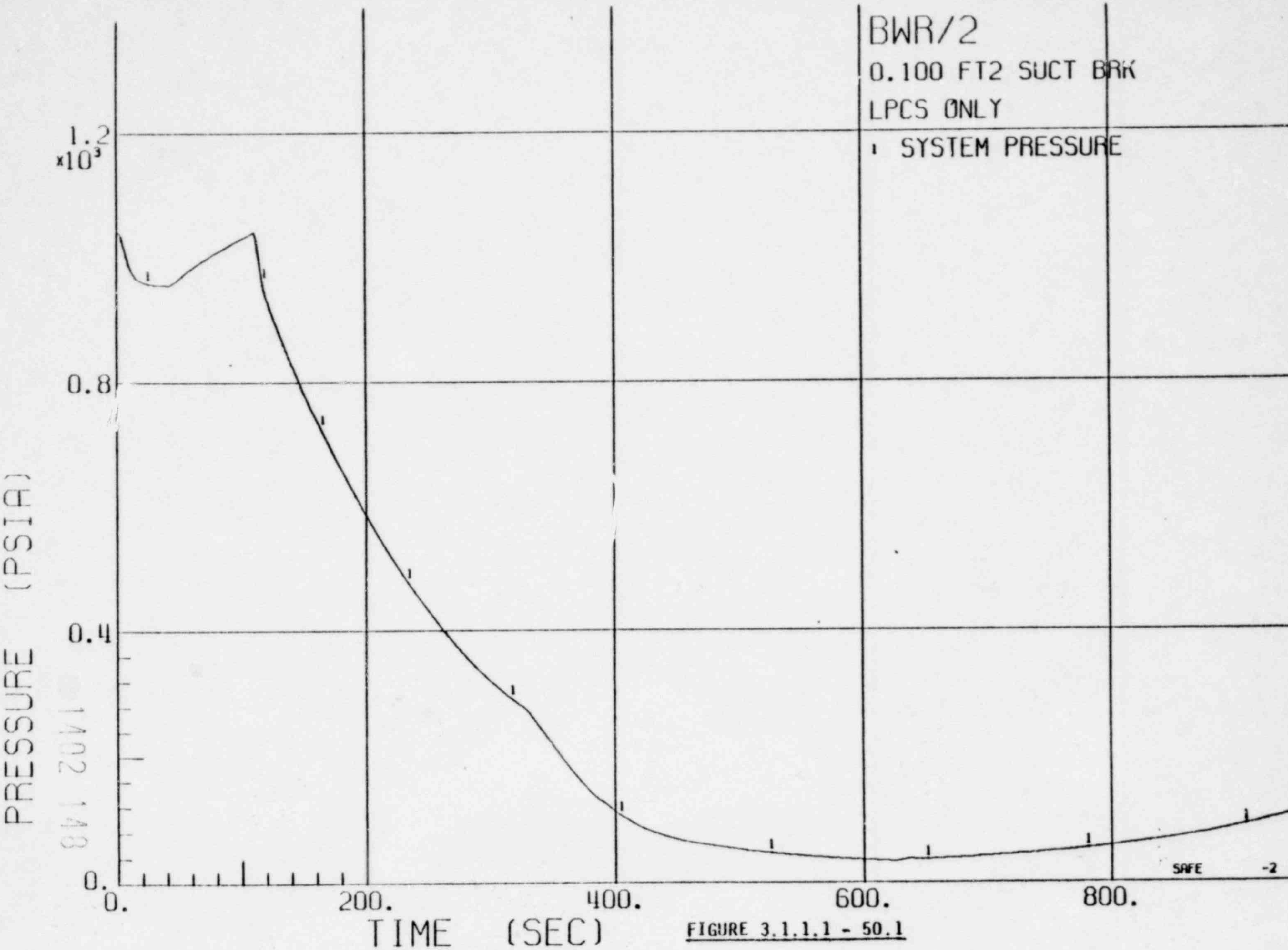


FIGURE 3.1.1.1 - 50.1

1402 148

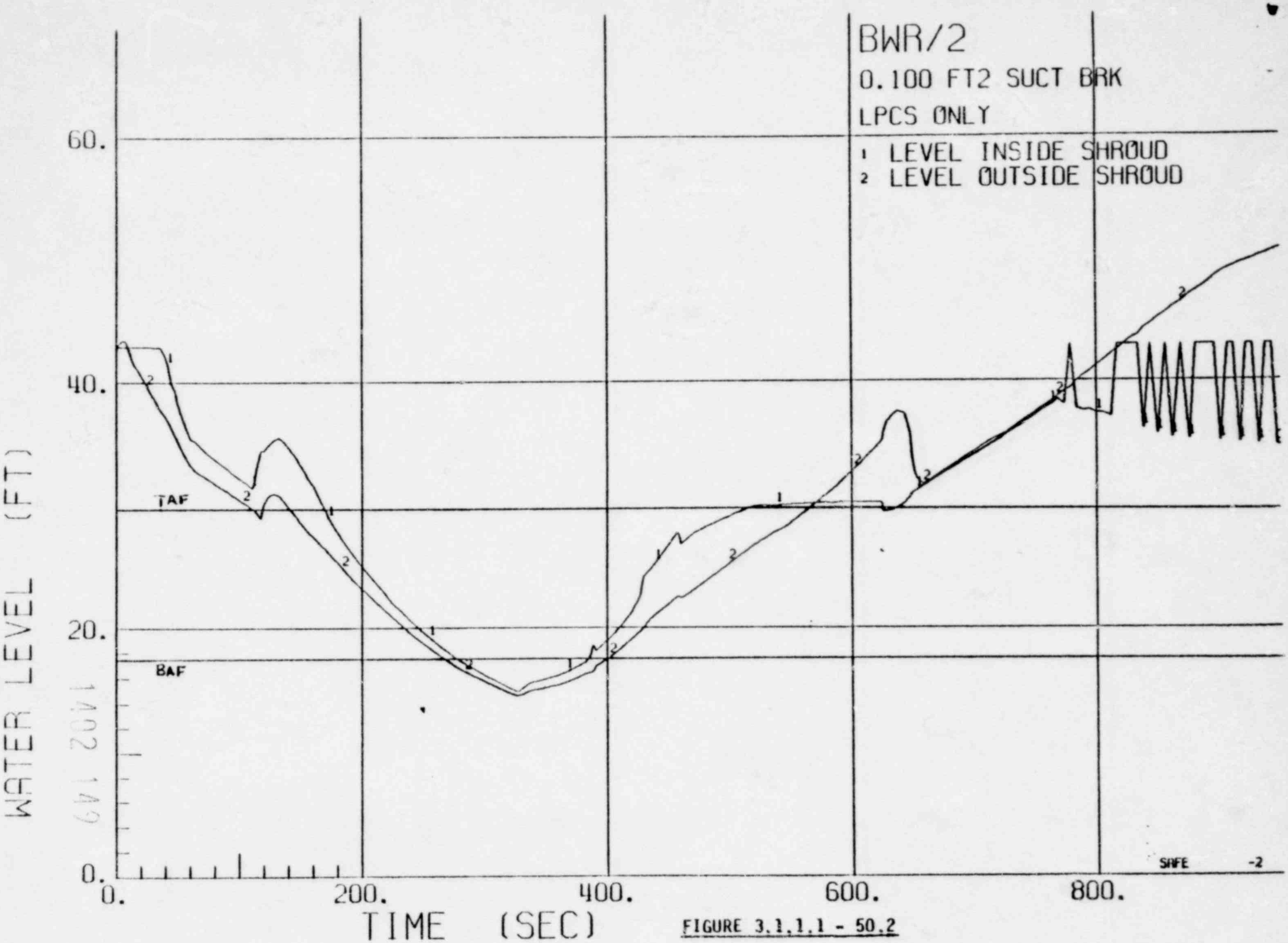


FIGURE 3.1.1.1 - 50.2

1402 149

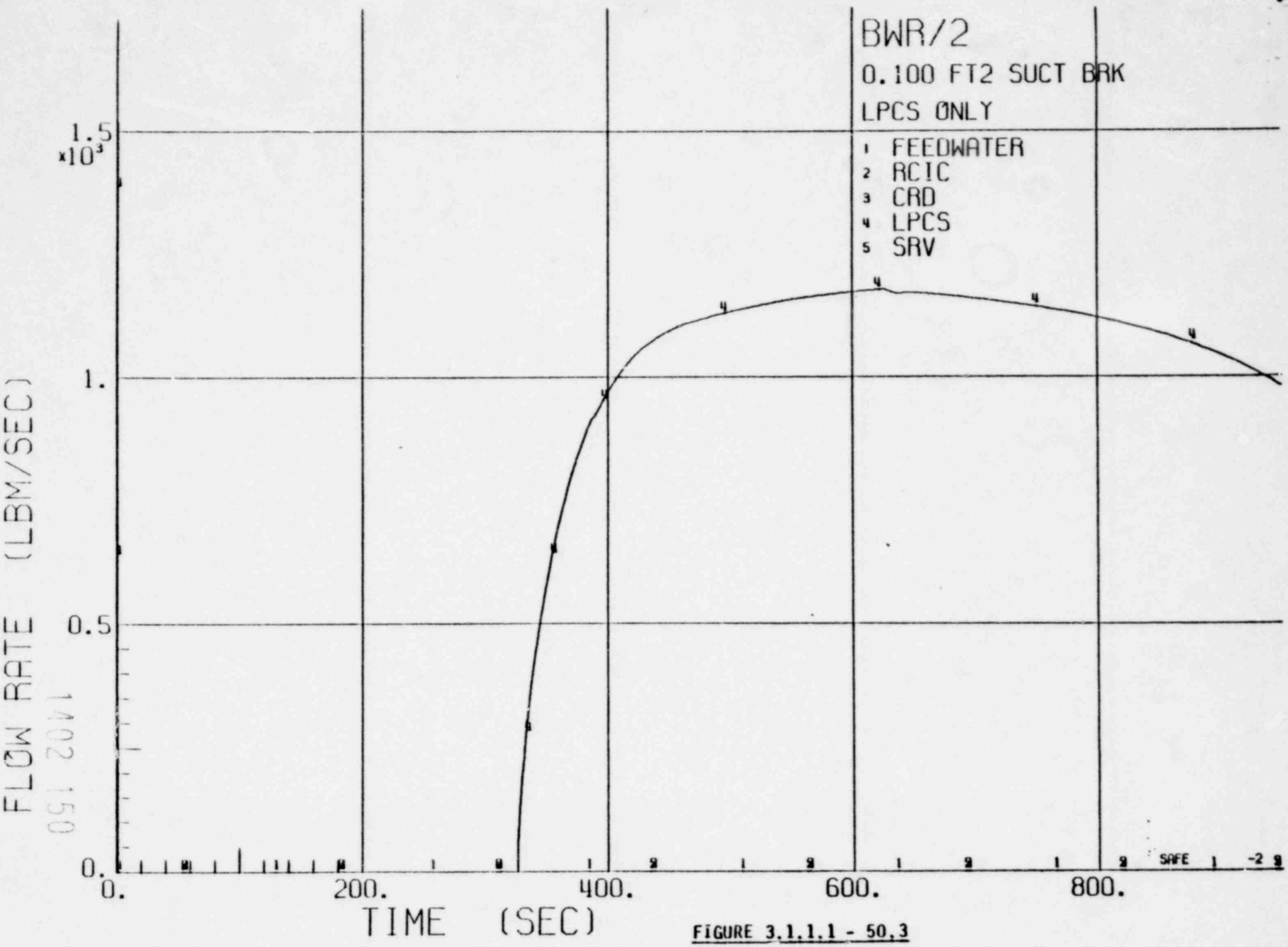


FIGURE 3.1.1.1 - 50.3

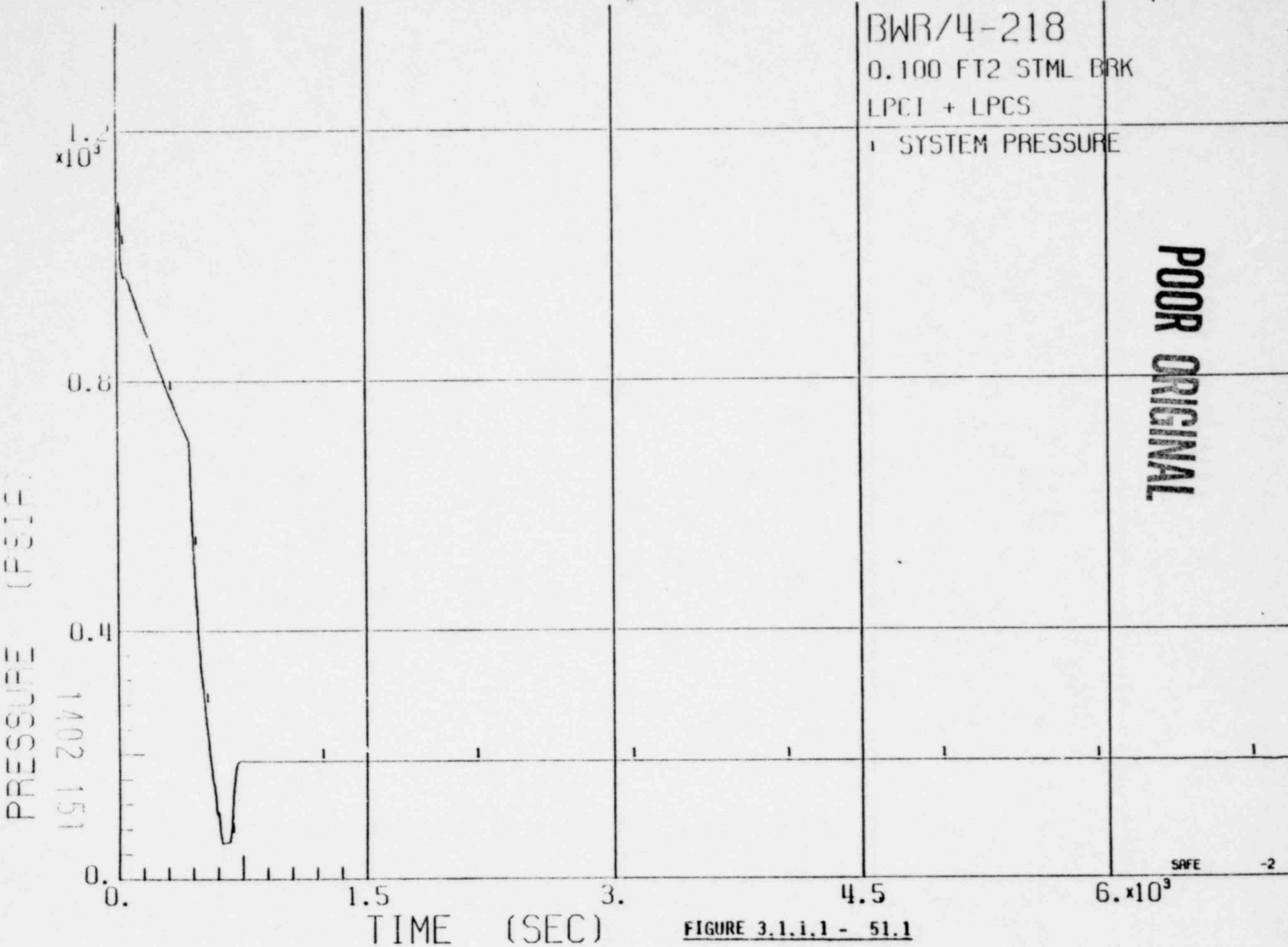


FIGURE 3.1.1.1 - 51.1

1402 151

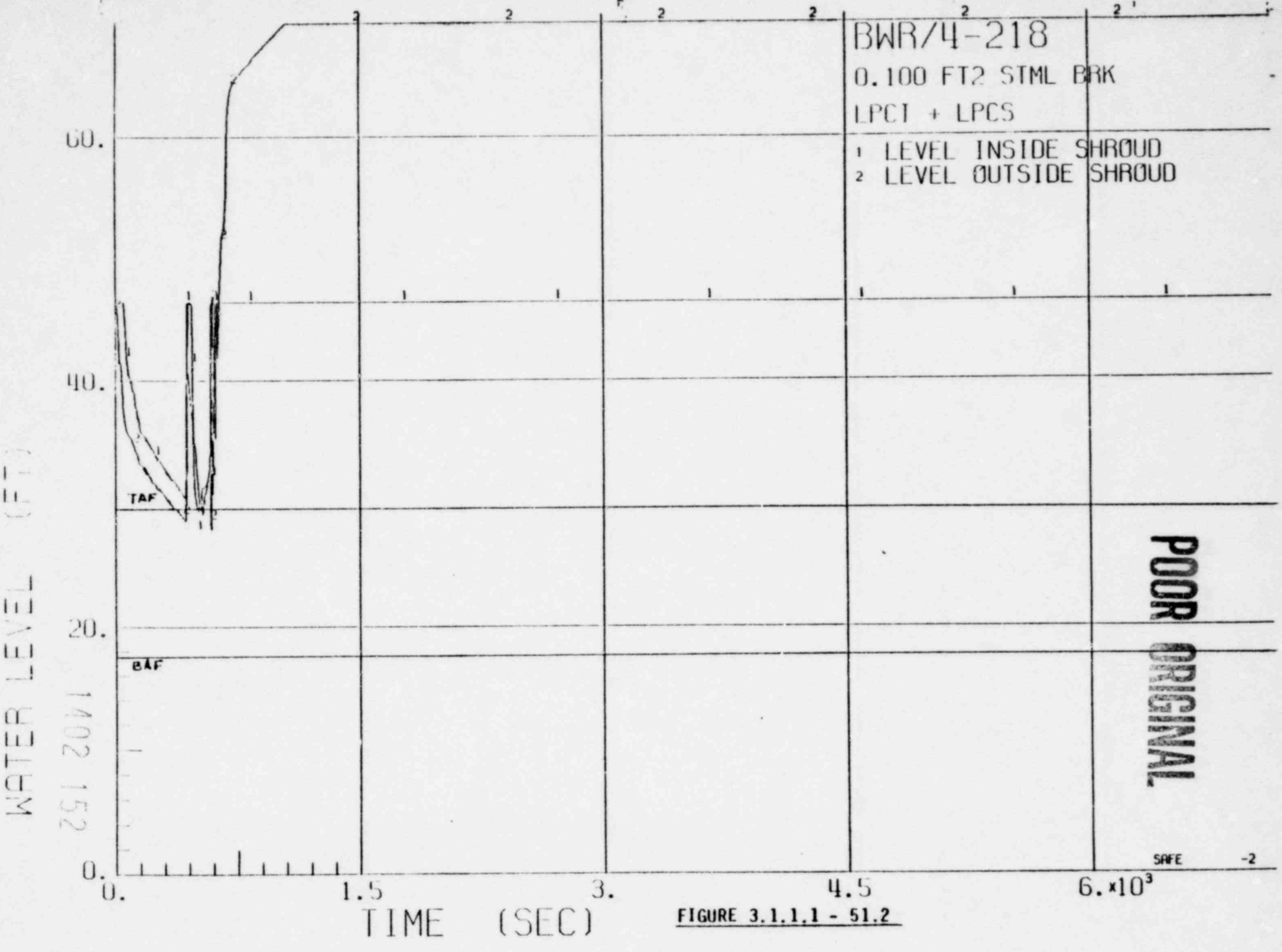


FIGURE 3.1.1.1 - 51.2

POOR ORIGINAL

1402 152

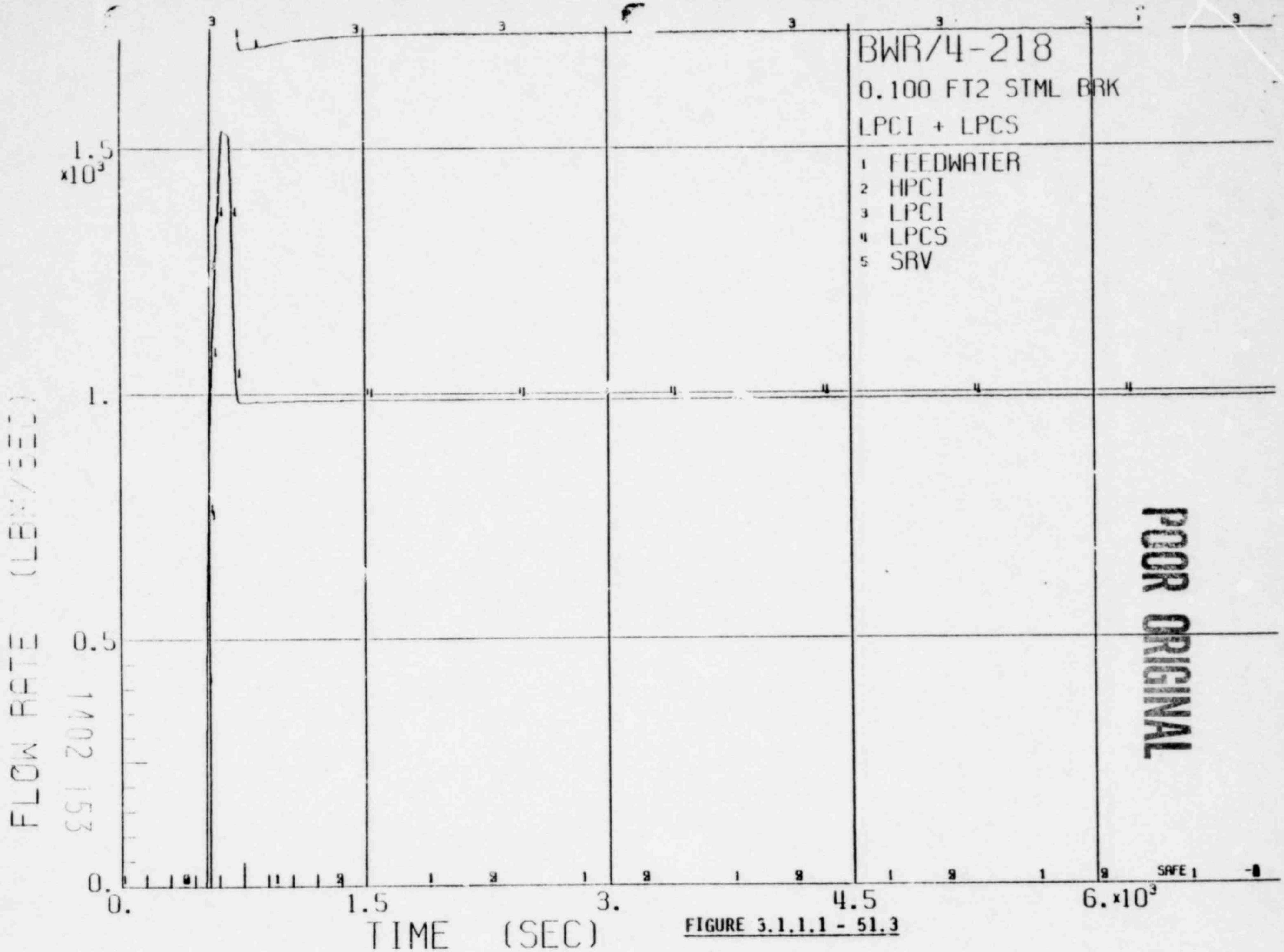


FIGURE 3.1.1.1 - 51.3

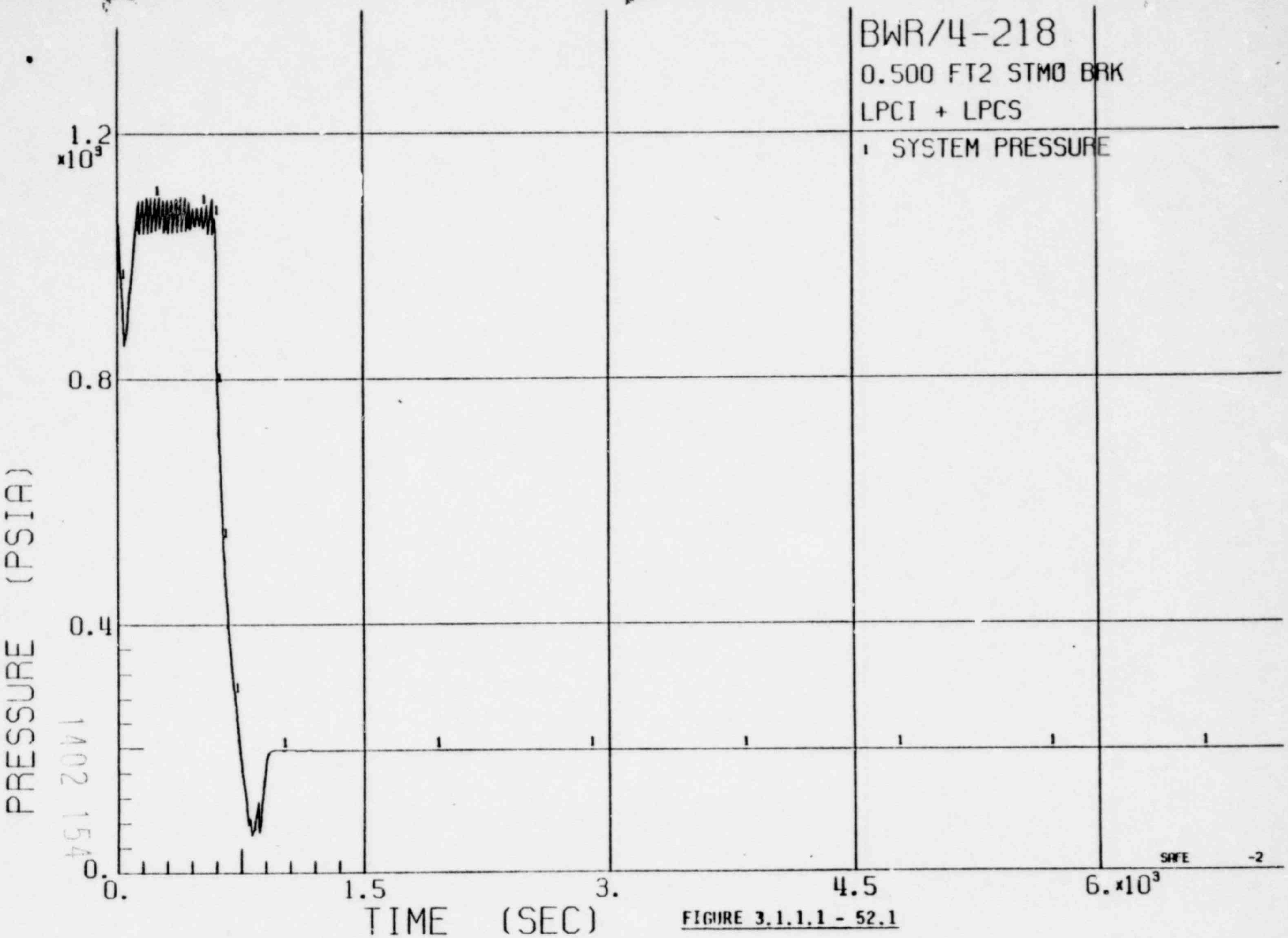


FIGURE 3.1.1.1 - 52.1

1402 154

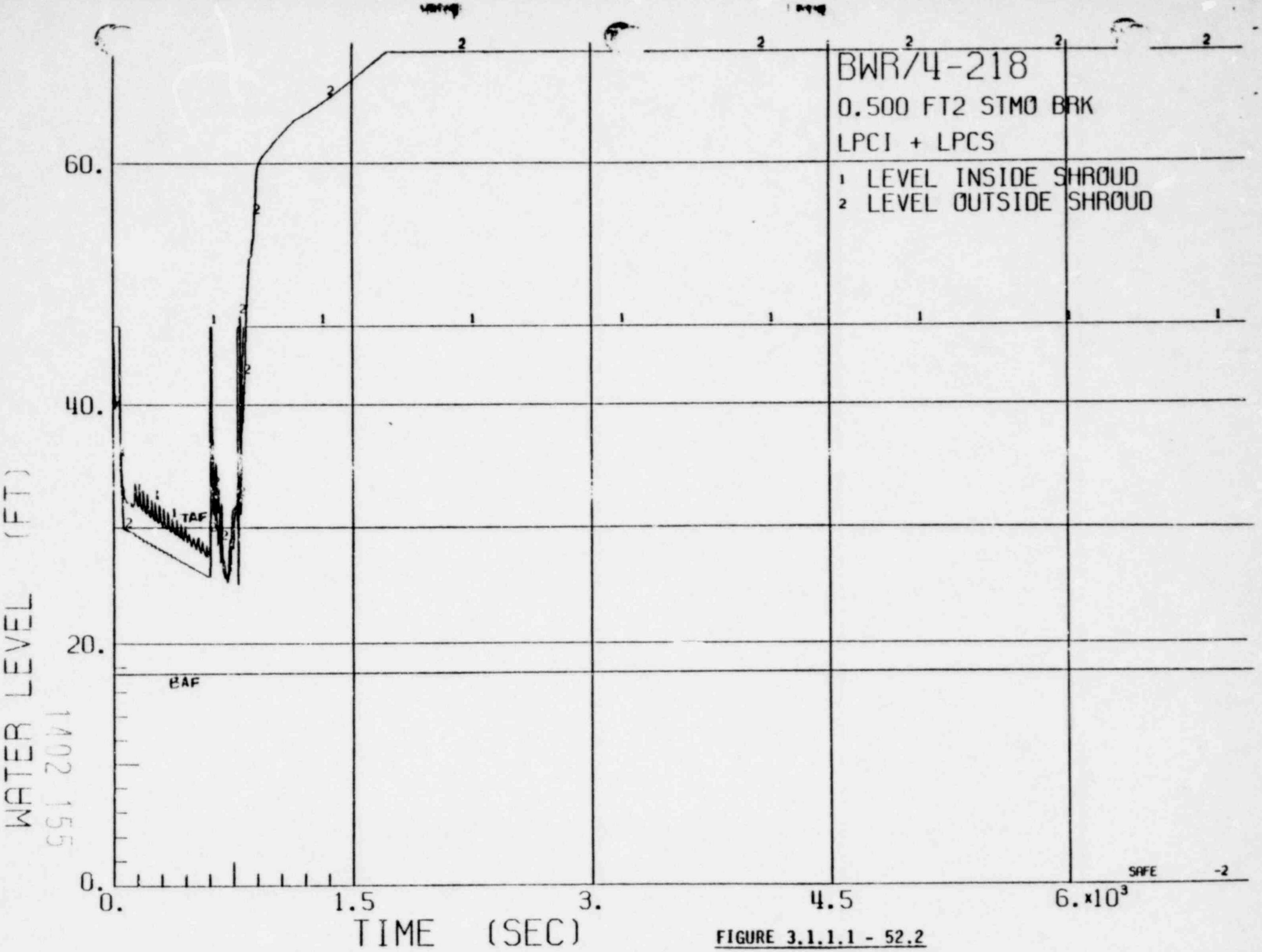


FIGURE 3.1.1.1 - 52.2

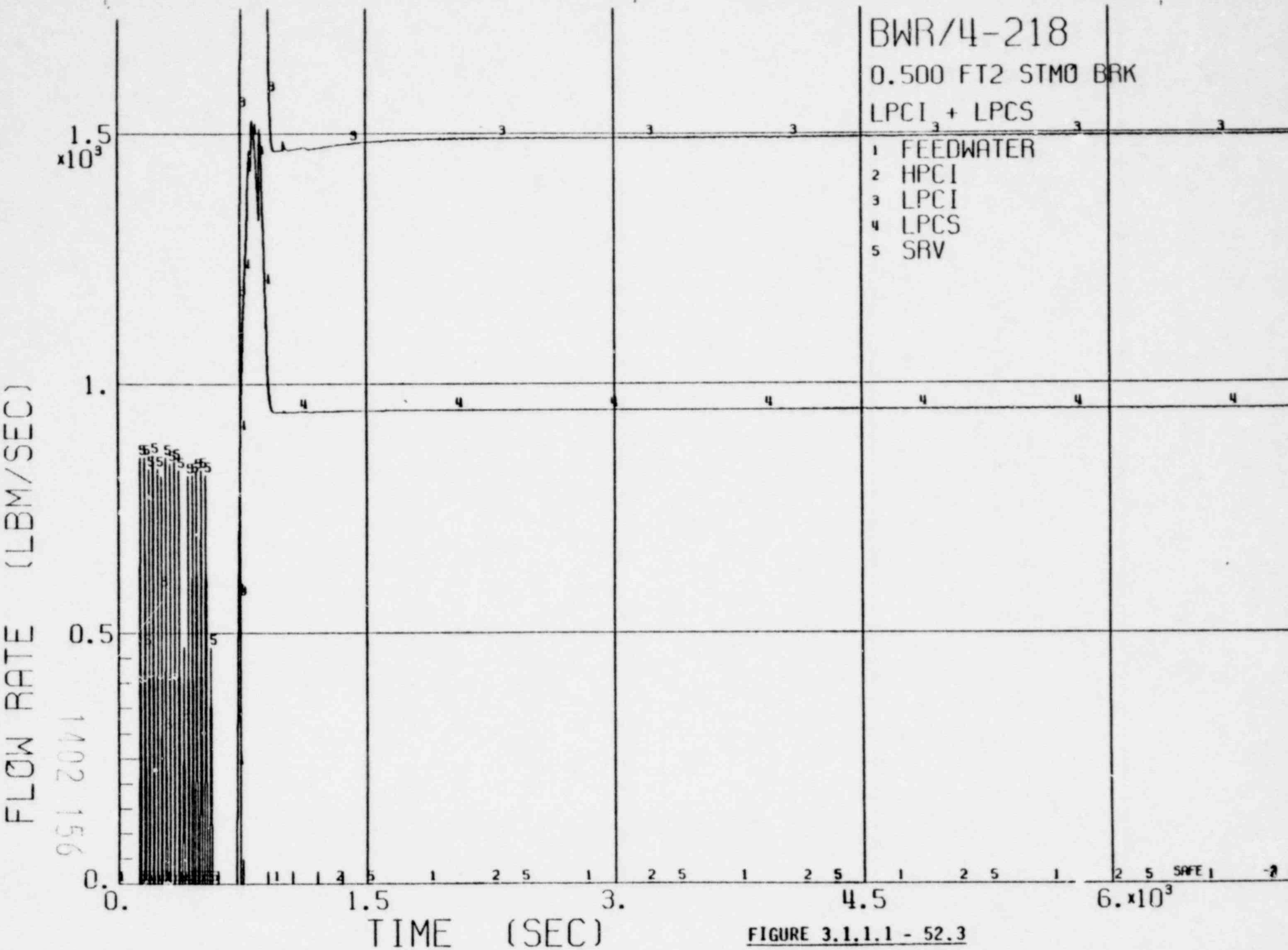


FIGURE 3.1.1.1 - 52.3

1402 156

DEGRADED CASES

RCIC + CRD

- EFFECT OF BREAK LOCATION
- CAN HANDLE CERTAIN RANGE OF BREAK SIZES

HPCS/HPCI + CRD

- DEMONSTRATE DIFFERENCES BETWEEN HPCI/HPCS AND RCIC

HPCS + CRD

- DEMONSTRATE DIFFERENCES BETWEEN HPCS AND HPCI

FEEDWATER + CRD

- DEMONSTRATE ABILITY OF FEEDWATER TO MAINTAIN LEVEL

LP SYSTEMS ONLY

- DEMONSTRATE SYSTEM RESPONSE FOR NO HP SYSTEMS

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OPERATOR ACTIONS

DEGRADED CASES

- VERIFY THAT SYSTEM MAINTAINS OR RESTORES LEVEL

- MANUAL ADS IF ISOLATED AND OUTSIDE BREAK

- THROTTLE SYSTEMS ONCE LEVEL RESTORED

1402 158

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OTHER CONCERNS

NO BREAK

- SIMILAR TO OUTSIDE STEAMLINE BREAK
- RCIC, HPCI, HPCS, OR FW CAN MAINTAIN LEVEL
- IF NO HIGH PRESSURE SYSTEMS AVAILABLE MANUALLY ADS

STUCK OPEN RELIEF VALVE

- DEPRESSURIZES SYSTEM

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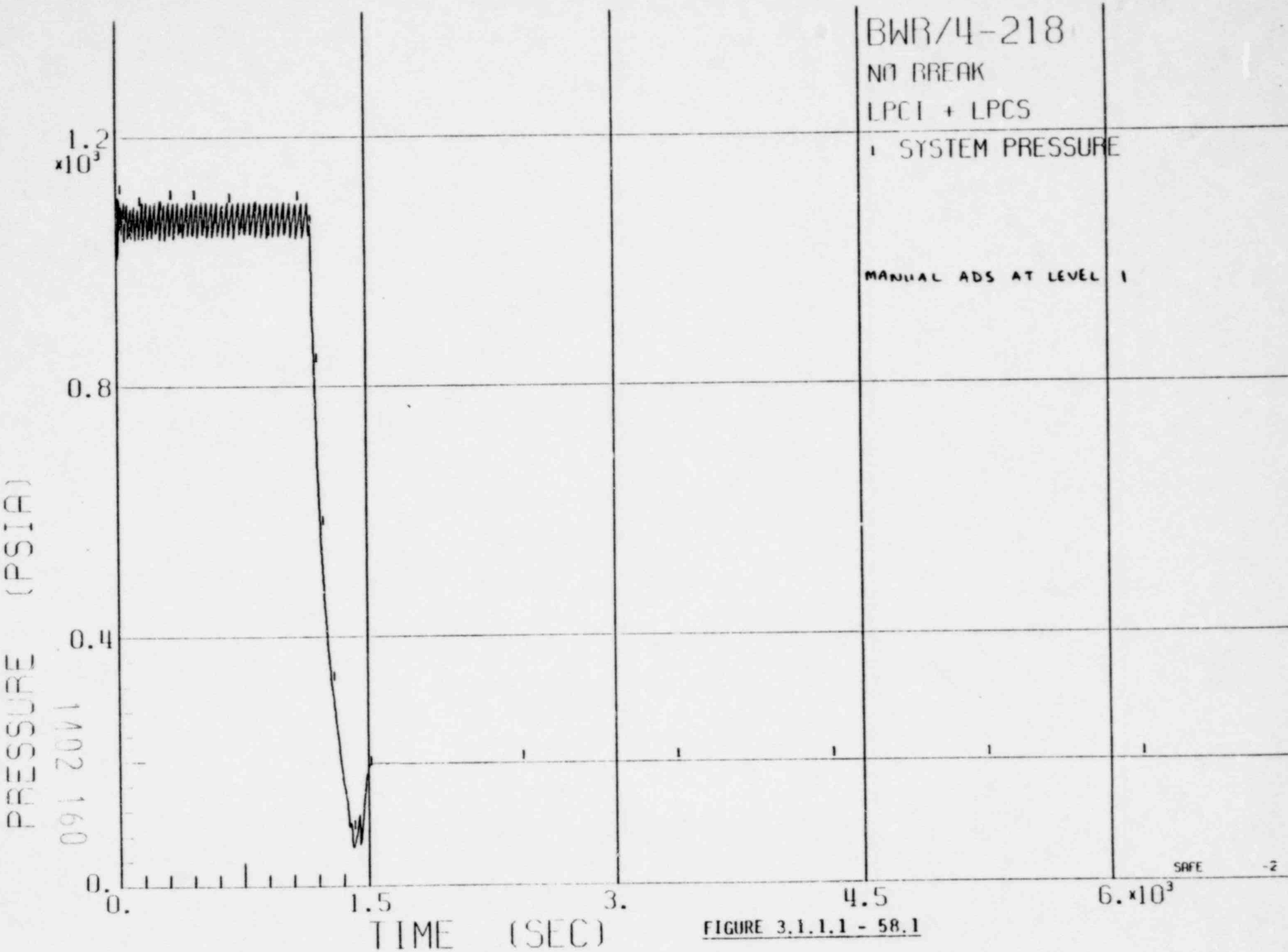

FIGURE 3.1.1.1 - 58.1

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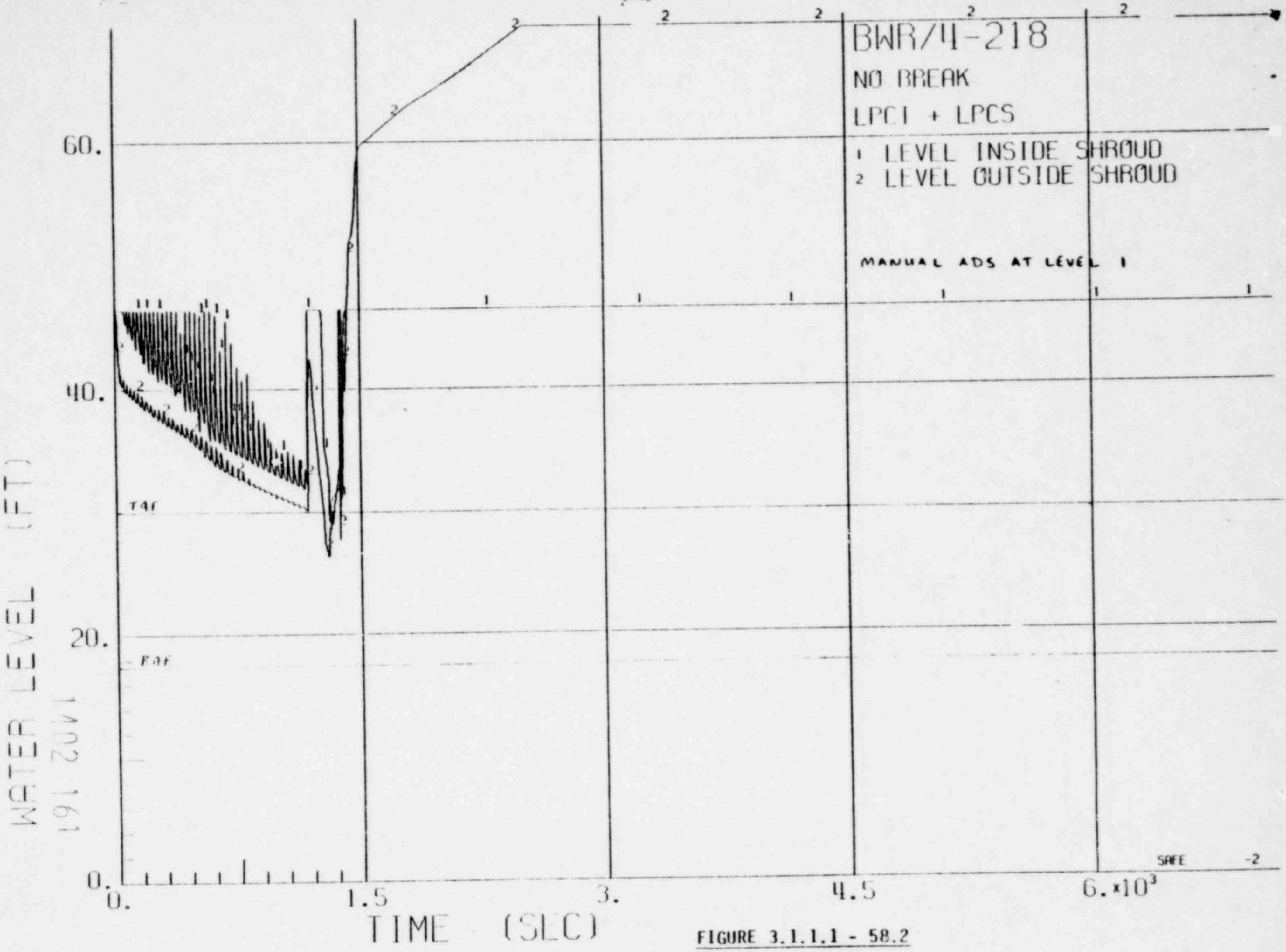

FIGURE 3.1.1.1 - 58.2

1402 161

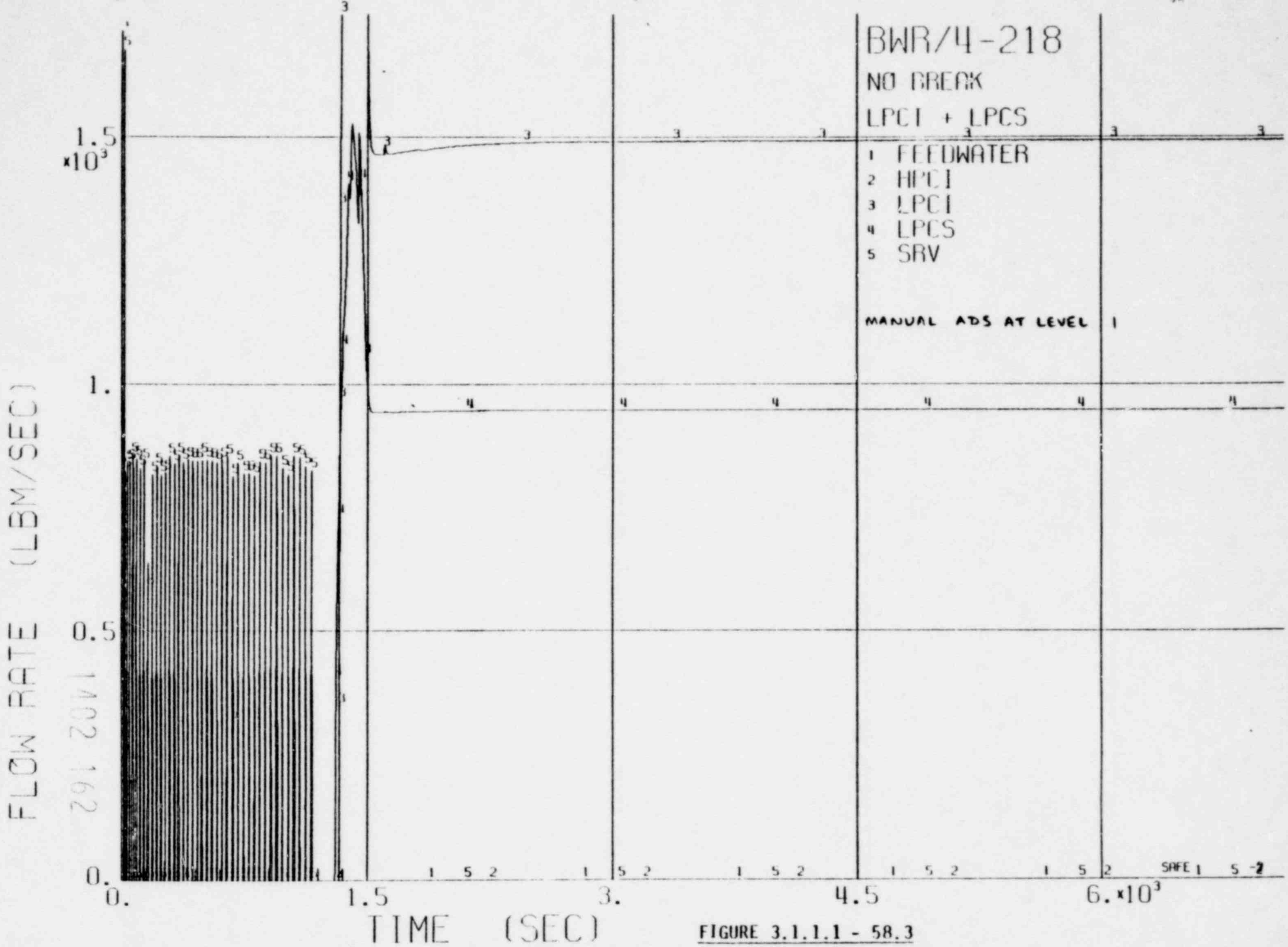

FIGURE 3.1.1.1 - 58.3

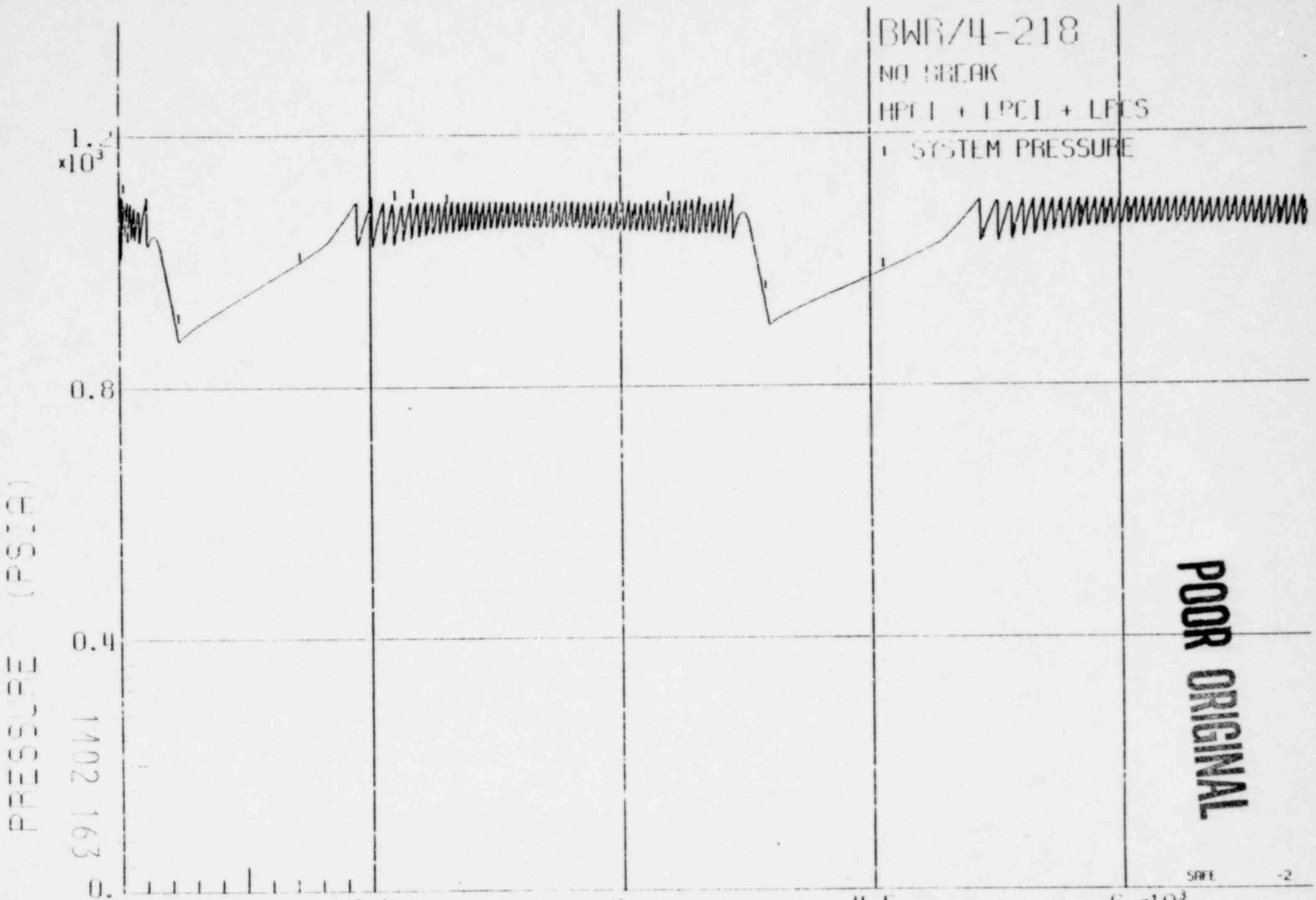

FIGURE 3.1.1.1 - 56.1

POOR ORIGINAL

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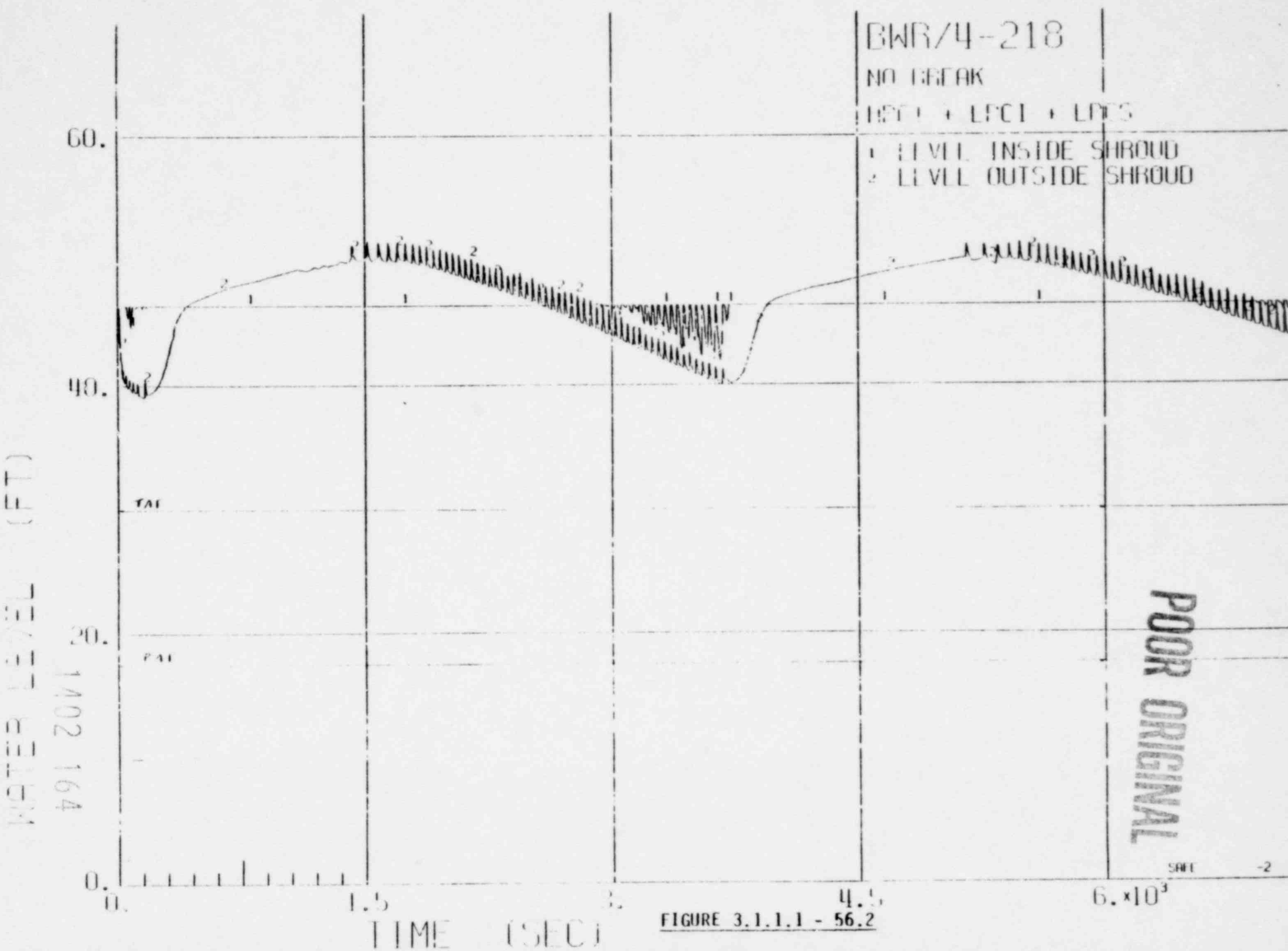

FIGURE 3.1.1.1 - 56.2

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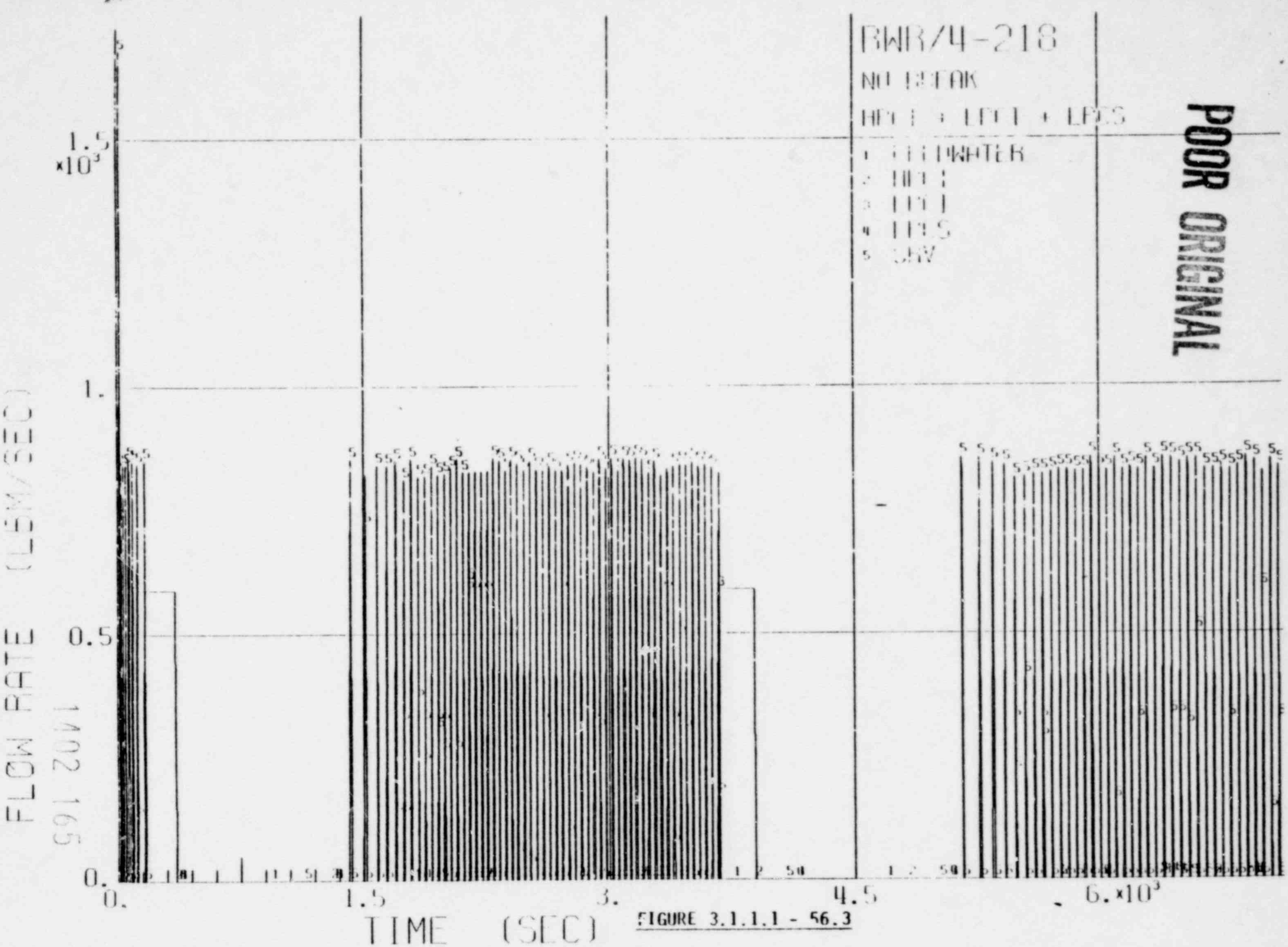

FIGURE 3.1.1.1 - 56.3

POOR ORIGINAL

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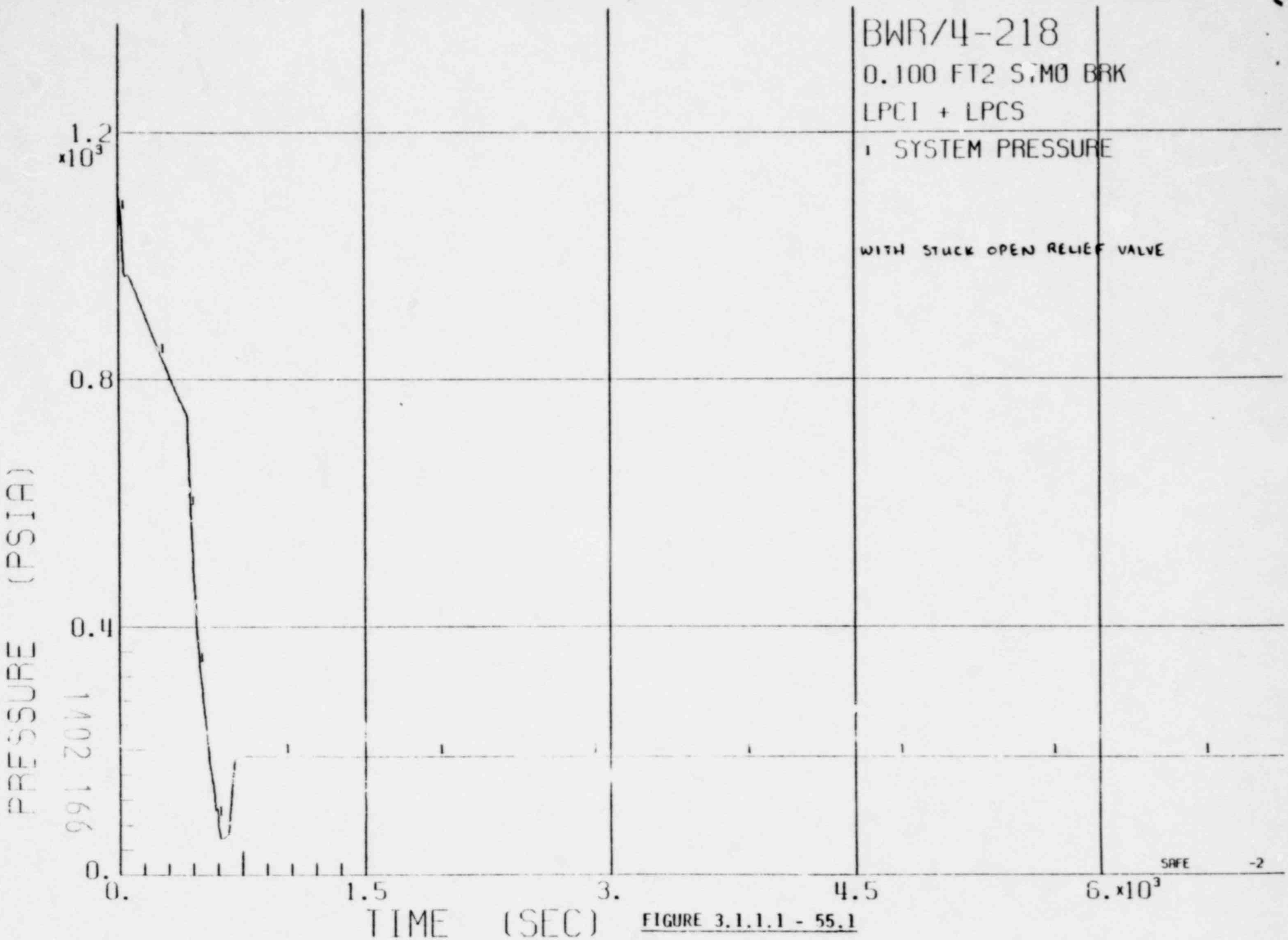

FIGURE 3.1.1.1 - 55.1

1402 166

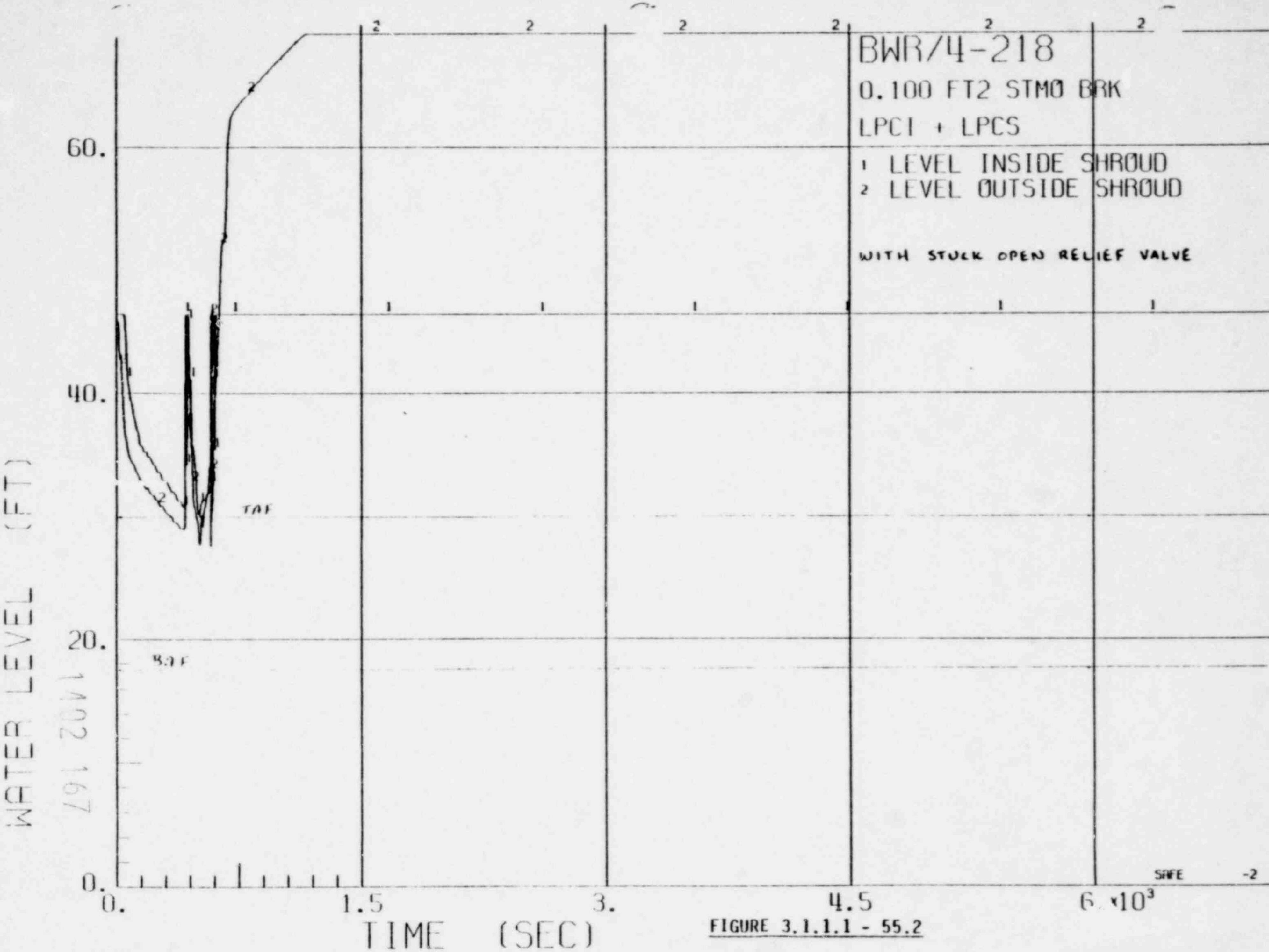

FIGURE 3.1.1.1 - 55.2

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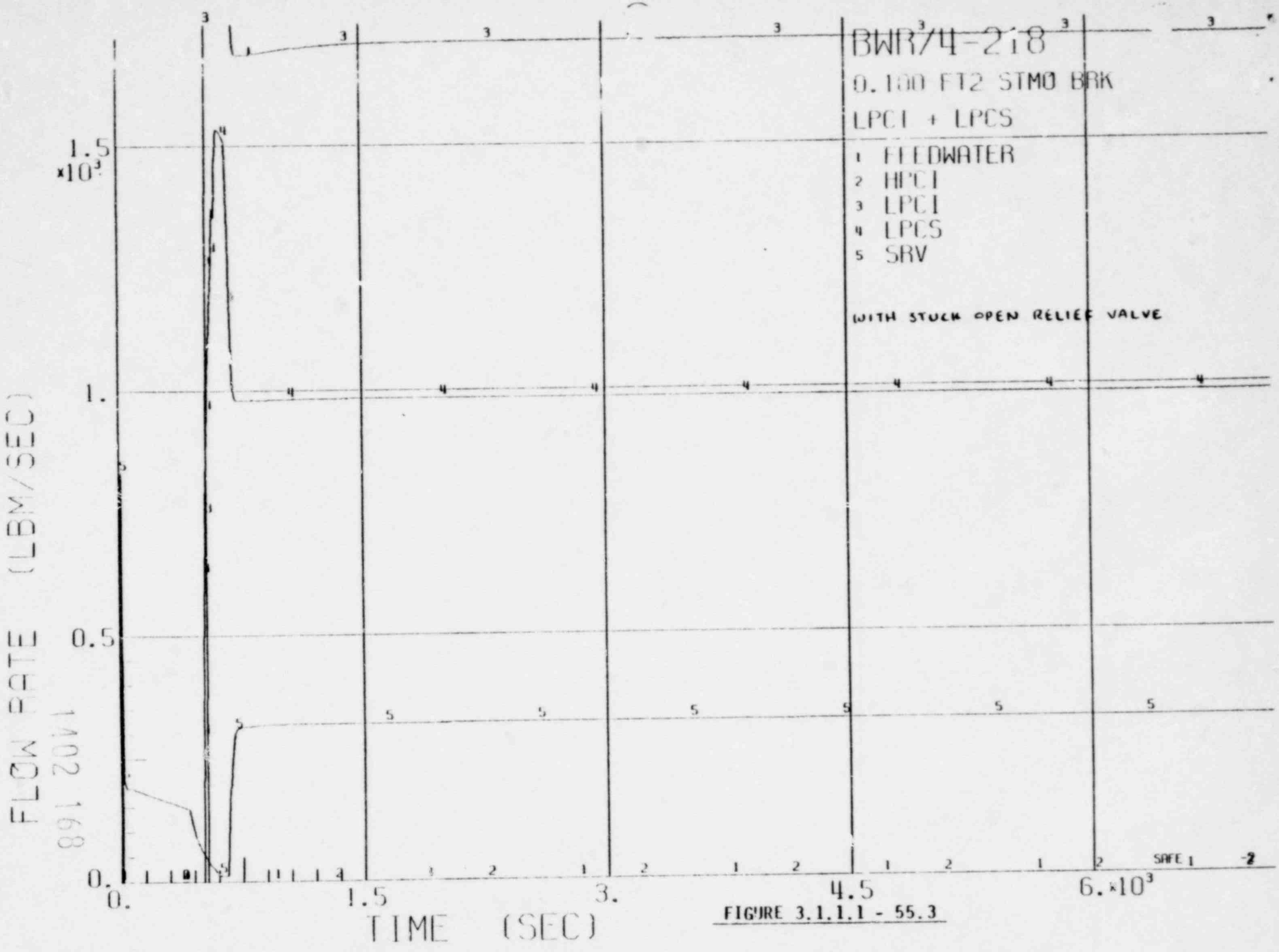

FIGURE 3.1.1.1 - 55.3

1402 168

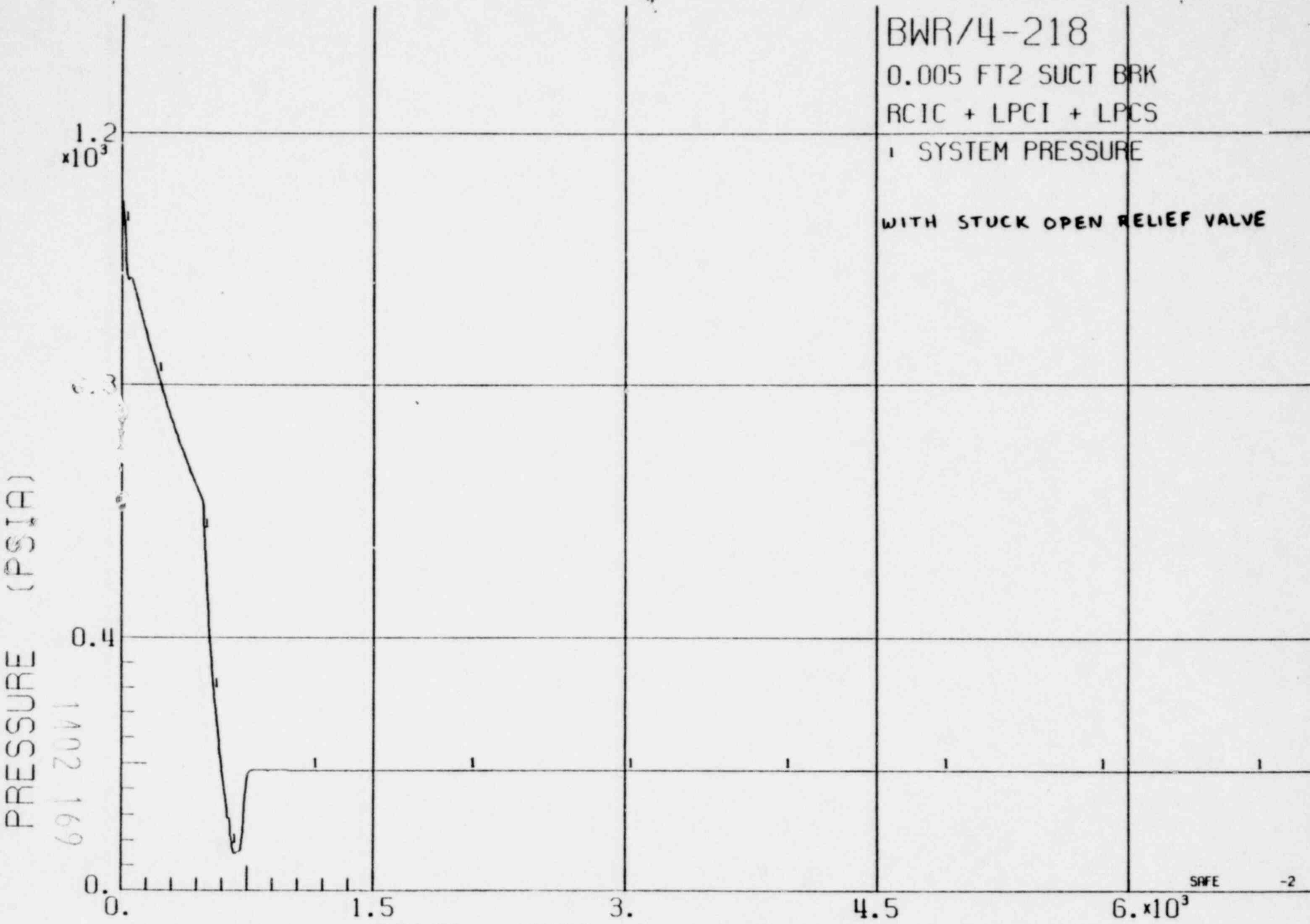

FIGURE 3.1.1.1 - 53.1

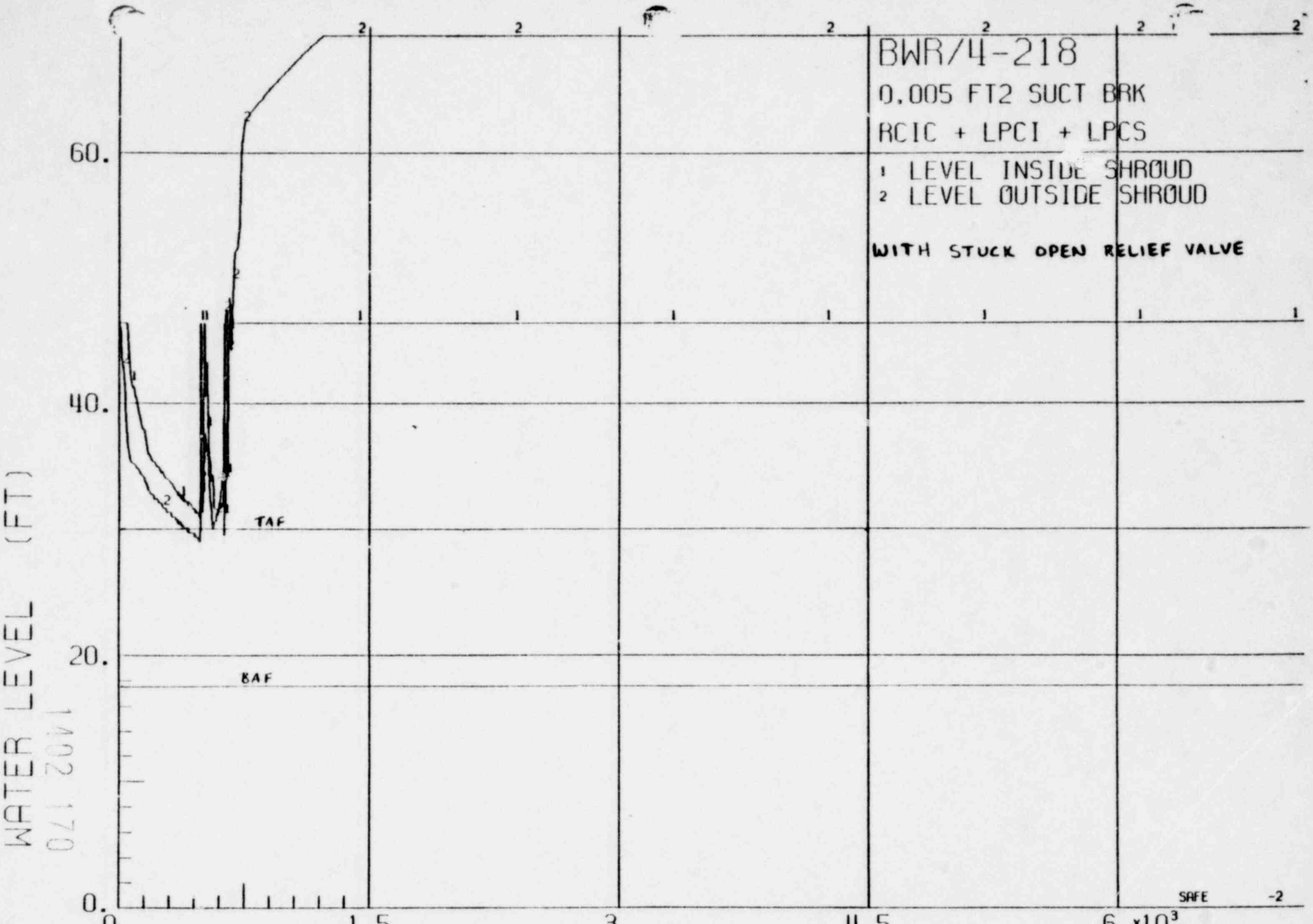

FIGURE 3.1.1 1 - 53.2

1402 170

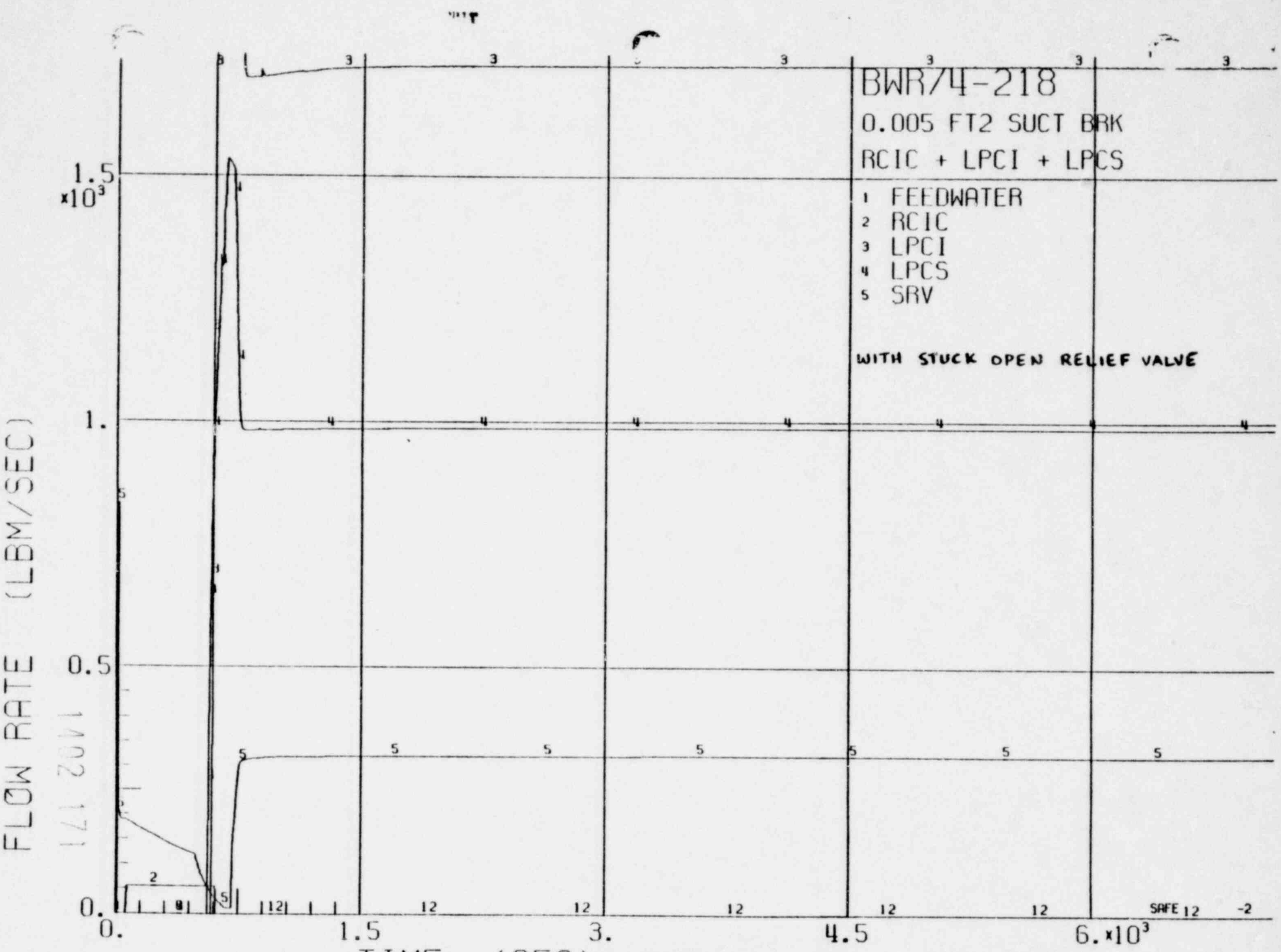

FIGURE 3.1.1.1 - 53.3

SUMMARY

- BREAKS INSIDE THE CONTAINMENT

  IMMEDIATE OPERATOR ACTIONS

  - VERIFY AUTOMATIC ACTIONS
  - MONITOR WATER LEVEL
  - CONTROL HIGH PRESSURE SYSTEMS TO PREVENT OVERFILLING VESSEL
  - VERIFY LOW PRESSURE SYSTEM INJECTION

  SUBSEQUENT OPERATOR ACTIONS

  - CONTROL LOW PRESSURE SYSTEMS TO PREVENT OVERFILLING VESSEL
  - COOL SUPRESSION POOL
  - CONTROL CONTAINMENT PRESSURE
  - FOLLOW POST-LOCA HYDROGEN CONTROL PROCEDURES

- BREAKS OUTSIDE THE CONTAINMENT

  IMMEDIATE OPERATOR ACTIONS

  - SAME AS FOR BREAKS INSIDE CONTAINMENT EXCEPT NO AUTOMATIC ADS, NO LOW PRESSURE SYSTEM INITIATION

  SUBSEQUENT OPERATOR ACTIONS

  - NORMAL OPERATION
  - ISOLATION RECOVERY
  - DEPRESSURIZE THE VESSEL FOR POOL COOLING CONSIDERATION

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3.1.1.2 Operator Guidelines

Introduction

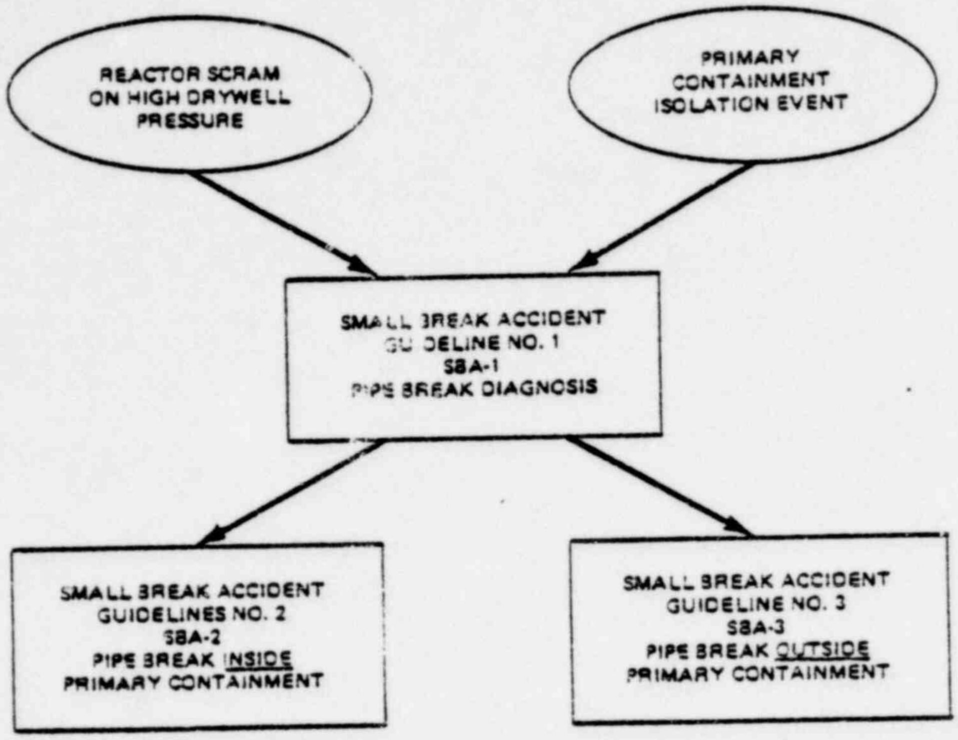
Based on the analyses discussed in Sections 3.1.1.1 and the design of the various reactor systems, a set of operator guidelines has been developed. These guidelines define operator actions following a loss of coolant accident at rates large enough to cause one or both of two automatic actions: a) reactor scram on high drywell pressure, and/or b) initiation of the primary containment isolation system. It should be noted that a small pipe break inside the primary containment will cause a reactor scram from high drywell pressure. Losses of coolant at lesser rates are considered leaks, instead of breaks, and are not covered in these guidelines. Technical Specifications and existing utility procedures require the operator to shut down the plant whenever: a) total leakage exceeds [25]* gpm, and b) unidentified leakage exceeds [5] gpm. (A 25 gpm leak corresponds to a liquid break size of 0.0005 ft^2, or a circular hole of diameter 0.3 inch.)

Effectively, occurrence of one of the two above automatic actions defines "time zero" for the accident. The break may occur prior to "time zero", but the time interval between the break and "time zero" is unimportant. After the break occurs, plant protective instrumentation will sense the break, and cause either a scram and/or an isolation. If the operator sees the break symptoms before automatic scram and/or isolation, and manually initiates scram and/or isolation, so much the better. These guidelines would not be written differently, except perhaps to note that the scram and/or isolation was manual instead of automatic.

*[ ] indicates plant specific value.

1402 173

The following section has three guidelines, organized as follows:



The first guideline, SBA-1, is diagnostic and provides an entry point for the second and third guidelines, SBA-2 and SBA-3. Guidelines SBA-2 and SBA-3 contain specific recommendations. They each have 4 major headings:

1. Purpose

2. Symptoms and Automatic Actions

   "Symptoms" are process variable indications or alarms which the operator is expected to see or hear in the control room.

   "Automatic Actions" are actions taken by the plant protective instrumentation and associated systems without assistance from the operator.

1402 174

3. Immediate Operator Actions

"Immediate Operator Actions" are actions the operator takes as soon as possible to protect the core. The goals of Immediate Operator Actions ~~is~~ are to reduce the loss of primary inventory as quickly as possible, and to minimize the immediate release of radioactivity outside the containment. Immediate Operator Actions include, as first actions, the verification of Automatic Actions, and are done before any further manual actions are taken. Verification means the operator confirms that the Automatic Actions have been correctly performed by checking multiple indications which should change as a result of the Automatic Action. For example, the operator verifies reactor scram by noting all control rod position lights show rods fully inserted, and that the neutron flux indicators show decaying flux. As a second example, the operator verifies HPCI initiation by noting indications on flow, turbine rpm, valve positions, pump discharge pressure, etc., in addition to the annunciator that signals HPCI start.

As a third example, the operator manually initiates RCIC if RCIC does not automatically start on low vessel level.

4. Subsequent Operator Actions

"Subsequent Operator Actions" are actions the operator should take after the Immediate Operator Actions. The goal of the Subsequent Operator Actions is to bring the plant to a stable condition, where the vessel water level is steady or cycling within a satisfactory range, and containment cooling has been established.

Within these major headings, an effort has been made to list the more important items first and the less important items last. Plant specific values are enclosed in brackets [ ]. Utility-prepared procedures should contain the specific alarm window numbers, setpoint values, panel locations, notification instructions, valve numbers, and reference to other applicable accident or emergency procedures.

1402 175

Also within some of the headings, caution statements have been added. "Cautions" are advice to the operator not to take certain actions which might increase the severity of the consequences, or to be aware of key indications during the course of the accident. Cautions are included in the guidelines where appropriate.

The guidelines contained within this report are generic to all GE-BWR's in that they include all systems which may be used to mitigate the consequences of a small break accident, (i.e. HPCI, RCIC, LPCS, LPCI, CRD, and ADS). Because any specific plant may not include all of the above systems, care must be exercised by the individual plant operator when applying these guidelines. The guidelines will be applied to individual plants by either not considering statements from the guidelines which are not applicable, or by substituting corresponding systems. For example, plants with no LPCI will not consider statements referring to LPCI, and plants with isolation condensers will substitute IC for RCIC. In this manner the guidelines apply to all plants.

All systems function normally, including feedwater and condensate systems, off-site power, instrument air, control rod drive pumps, and isolation valves. Degraded cases (such as loss of high pressure systems or failure of valves to close) are considered under contingencies. Contingencies for failed equipment are contained within the guidelines; separate guidelines are not provided. However, it is expected that the current utility procedures concerning equipment out of service will be referenced where applicable.

1402 176

SMALL BREAK ACCIDENT GUIDELINE #1

SBA-1

PIPE BREAK DIAGNOSIS

PURPOSE

There are four basic objectives the operator is to achieve in the event of a pipe break, with respect to the core and containment:

a. Maintain core cooling to prevent excessive cladding heatup and oxidation;

b. Limit the release of offsite radiation by maintaining the integrity of the primary and secondary containments;

c. Place the reactor in a safe, stable condition;

d. Keep the pool bulk temperature below [°F] to prevent excessive loads to the pool boundary and structures during safety/relief valve discharges, and maintain peak allowable temperatures within cooling equipment and containment structure design limits.

This guideline, SBA-1, provides the entry point for the two following guidelines, which include specific recommendations depending on the break location:

Small Break Accident Guideline SBA-2: Pipe Break Inside Primary Containment
Small Break Accident Guideline SBA-3: Pipe Break Outside Primary Containment

Guidance is provided to the operator in diagnosing the symptoms displayed in the control room so that he may distinguish between small pipe breaks inside the primary containment and small pipe breaks outside the primary containment, and to select the appropriate guideline.

1402 177

GENERAL OPERATOR AWARENESS ITEMS

This section provides "cautions" which are common to both guidelines SBA-2 and SBA-3. These items must be kept in mind at all times during the course of a pipe break accident.

CAUTION #1

Operators should be prepared to take immediate actions as necessary to protect the core and containment. Immediate Operator Actions include verification of Automatic Actions and taking manual action to initiate an automatic function whenever an Automatic Action did not occur that should have occurred.

CAUTION #2

Continuously monitor vessel level and pressure from multiple indications.

CAUTION #3

On any automatic initiation of a safety function, assume a true initiating event has occurred, until otherwise confirmed by two or more independent process indications.

CAUTION #4

Automatic controls should not be placed in MANUAL mode, unless 1) misoperation in AUTOMATIC mode is confirmed by at least two independent process parameter indications; or 2) core cooling is assured, and these guidelines state specifically to do otherwise. When manual operation is no longer needed, restore the system to AUTOMATIC/STANDBY mode, if possible.

CAUTION #5

Any emergency core cooling system should not be shut off unless there are multiple confirming process parameter indications (such as level indications from several instruments) that the core and containment are in a safe, stable condition.

CAUTION #6

If any system is switched from AUTOMATIC to MANUAL mode, then frequent checks of the controlled parameter must be made.

ENTRY POINT EVENTS

1. If a reactor scram occurs from a high drywell pressure signal, then go to SBA-2, "Pipe Break Inside Primary Containment".

2. If any one or more of the primary piping isolation valve groups isolates, then go to SBA-3, "Pipe Break Outside Primary Containment".

1402 179

SMALL BREAK ACCIDENT GUIDELINE #2

SBA-2

PIPE BREAK INSIDE PRIMARY CONTAINMENT

1. PURPOSE

The intent of this guideline is to assure that the normal water makeup systems, the Emergency Core Cooling Systems (ECCS), and containment cooling systems operate as designed to protect the core and containment in the event of a Small Break Accident (SBA) inside the primary containment. In the guideline are described events to be expected and operator actions which are required to bring the reactor and containment to a controlled, stable condition. Also included in this guideline are the operator actions following loss of the high pressure water make-up systems.

2. SYMPTOMS AND AUTOMATIC ACTIONS

The symptoms and automatic actions which are displayed in the control room in the event of a pipe break inside the primary containment are grouped below ~~according to initiating signal~~. The symptoms observed will depend upon the severity of the accident. For smaller breaks, only the first few symptoms may be observed. For a larger break, more symptoms would be expected. ~~Automatic Actions, which generally occur, are listed under each symptom.~~

2.1 Symptoms

2.1.1 Drywell atmosphere symptoms

- ~~Increasing pressure~~
- High drywell pressure alarm [1.5 psig]
- High ~~or increasing~~ temperature
- High ~~or increasing~~ humidity
- High ~~or increasing~~ radiation

2.1.2 Drywell Sump Symptoms

- High or high-high levels
- High integrator readings
- High sump ~~or increasing~~ temperature
- Excessive sump pump operation

1402 180

2.1.3 Other Symptoms

- Generator load decrease
- Steam flow/feed flow mismatch
- Possible decrease in reactor water level
- Possible decrease in reactor pressure, unless MSIV isolation occurs, in which case reactor pressure can increase to S/RV setpoints

2.2 Automatic Actions

2.2.1 ECCS Actuations [2.0 psig]

- Emergency diesel-generators start
- HPCI starts and injects into the vessel [when vessel pressure is greater than the low pressure isolation setpoint of 100 psig]
- LPCI pumps start
- LPCS pumps start
- ADS high drywell pressure permissive

2.2.2 Other Automatic ~~Actuations~~ Actions

- Reactor scram [2.0 psig]
- Standby Gas Treatment System initiates [2.0 psig]
- Valve group [2] isolates [RHR shutdown cooling, drywell sumps, TIP system] [2.0 psig]
- Valve group [6] isolates [primary containment atmospheric control systems] [2.0 psig]
- Containment spray permissive [2.0 psig]

1402 181

2.5.2 Level

2.5.2.1 High level [8] [+58 inches] causes alarm and trip of feedwater, HPCI, RCIC

2.5.2.2 Low level [4] [+20 inches] causes alarm and recirculation pump runback, if feedwater is lost

[Additional low level Symptoms and Automatic Actions may be provided in the emergency procedures.]

3. IMMEDIATE OPERATOR ACTIONS

3.1 Any Automatic Actions listed in Section 2. above which should have initiated must be verified, preferably by at least two independent indications, or manually initiated if the Automatic Action did not occur.

* Scram is verified by noting that control rod position lights show rods fully inserted, and that neutron flux indicators show decaying flux. *

3.2 Take the reactor MODE switch out of RUN to prevent MSIV from closing on low vessel pressure [850 psig].

3.3 Continuously monitor vessel water level using all available instrumentation.

3.3.1 Narrow range level control indicators [instrument type, #s]

3.3.2 Wide range safety trip indicators [instrument type, #s]

3.3.3 Fuel zone indicators [instrument type, #s]

3.3.4 Refueling zone indicators [instrument type, #s]

CAUTION #7

The indicated water level, where provided by Yarway instrumentation utilizing reference legs in the drywell, is dependent upon drywell temperature. Very large increases in drywell temperature (an increase from 135°F to 340°F) could result in a level inaccuracy (as much as [28] inches depending on drywell temperature and type of instrument) with indicated level being higher than actual level.

During rapid reactor depressurization (with ADS operation for example), and particularly below 500 psig, the operator should utilize the cold reference leg type of level indicators (such as operating range and fuel zone indication) to give backup information on vessel water level. The operator should not turn off any ECCS unless there is sufficient confirming information from cold reference leg level instruments that vessel water level has been restored. The operator should not rely on the Yarways if erratic behavior, indicative of reference leg flashing, has occurred until the Yarway readings are on scale and in reasonable agreement with other (cold reference leg) types of level instruments. The operator should verify that automatic ECCS actuations occur when the levels are at the trip points (adjusted in accordance with each plant's individually verified recommendations). The operator should be prepared to manually actuate ECCS during a suspected LOCA if automatic actuation is not achieved.

3.4 Control vessel level with available high pressure systems (feedwater, control rod drive pumps, HPCI, RCIC). When the level approaches the high level [8] trip [+58 inches] for feedwater, HPCI, and RCIC, take manual control (if possible) of the high pressure systems to maintain level, and to prevent trips of feedwater, HPCI, and RCIC. Restore to AUTOMATIC/STANDBY mode (if possible) the systems which are not needed to maintain level. Make frequent checks of level when systems are in the MANUAL mode.

* If high pressure systems are unable to maintain level, then go to CONTINGENCY #1. *

CAUTION #8

If signals of high pool level or low condensate storage tank level occur, then manually transfer RCIC suction from the condensate storage tank to the pool, and verify automatic transfer of suction for HPCI.

CAUTION #9

Do not throttle HPCI and RCIC systems below turbine speeds which yield acceptable continuous operation.

3.5 If the vessel pressure falls below the shutoff head of the low pressure systems (condensate [300 psig], LPCS [300 psig], and LPCI [300 psig]), confirm that these systems inject into the vessel, and that the water level responds accordingly.

4. SUBSEQUENT OPERATOR ACTIONS

4.1 Continue to monitor and control vessel level. As vessel pressure decreases, maintain level with low pressure systems in the following order of preference: condensate, LPCS, then LPCI. Manually control flow to prevent water from flooding the steam lines. Shut off or direct to other cooling modes low pressure systems not needed to maintain level. One low pressure system must be dedicated to maintaining level.

> **CAUTION #10**
>
> If vessel pressure increases above the shutoff head of the low pressure systems being used to maintain level, then depressurize the vessel in the following order of preference: 1) condenser; 2) one or more SRVs to the pool (rotate use of SRVs to distribute heat uniformly to the pool); or 3) manual ADS initiation.

4.2 Continuously monitor and control pool temperature to keep the bulk pool temperature from exceeding [°F].

4.2.1 Re-establish main condenser as a heat sink, if possible.

> **CAUTION #11**
>
> Assure main steam lines are drained before opening main steam isolation valves.

4.2.2 As soon as the pool temperature exceeds the service water temperature, use the RHR pumps (if they are not needed in the LPCI mode for maintaining vessel level) in the normal pool cooling mode.

> **CAUTION #12**
>
> If vessel level cannot be maintained, then do not divert RHR pumps from the LPCI mode.

4.2.3 If the pool temperature reaches [°F], then manually depressurize the vessel to below [150 psig] using one or more SRVs. Rotate use of SRVs to distribute heat uniformly within the pool.

1402 184

4.3 Monitor and control containment pressure to keep pressure below design limit [62 psig].

4.3.1 If possible spray the pool airspace when the drywell pressure exceeds [2.0 psig].

4.3.2 If the drywell pressure exceeds [35 psig] for [10 minutes], then spray the drywell until pressure is reduced to [25 psig].

CAUTION #13

Do not operate recirculation pumps when spraying the drywell. Drywell spraying may put recirculation pumps out of service.

4.4 Follow procedures for post-LOCA containment venting and hydrogen control [procedure #s].

1402 185

CONTINGENCY #1

INABILITY TO MAINTAIN LEVEL WITH HIGH PRESSURE SYSTEMS*

If the operator determines that vessel level cannot be maintained by the high pressure systems, then the operator must verify automatic operation of the ADS on low level [1 plus 120 seconds preset time delay]. ~~[1] [-146 inches] and any time delay [120 seconds] in the ADS logic?~~ While waiting for the Automatic Actions to occur on decreasing vessel level, the operator should make all attempts to start the high pressure systems and regain level before the low level [1 plus 120 seconds preset time delay] ~~[1] [-146 inches]~~ is reached.

> **CAUTION #14**
>
> If the ADS does not initiate automatically on low level [1] [-146 inches], then manually initiate ADS (operator opens the same valves that the ADS logic would open automatically). Do not manually initiate ADS unless it is confirmed that at least one ~~the~~ low pressure pump~~s~~ [condensate, LPCS, LPCI] ~~are~~ is running. If the operator is unable to manually initiate ADS, then the operator must manually open other safety/relief valves. As many valves as possible, up to the number used for ADS, should be opened.

The operator should also verify those Automatic Actions which occur on decreasing level, and have not already occurred on high drywell pressure.

When the low level [1] [-146 inches] is reached, the operator should confirm that the ADS timer begins and that the proper valves open [120] seconds after the timer begins, if possible.

> **CAUTION #15**
>
> Do not block or defeat the ADS sequence by resetting the ADS timer, unless vessel level can be maintained.

After ADS actuates, return to Guideline SBA-2, Section 4, "Subsequent Operator Actions".

*includes failure of high pressure systems

1402 186

SMALL BREAK ACCIDENT GUIDELINE #3

SBA-3

PIPE BREAK OUTSIDE PRIMARY CONTAINMENT

1. PURPOSE

The intent of this guideline is to assure that the primary containment isolation system operates as designed in the event of a Small Break Accident (SBA) outside the primary containment. If the break occurs in a pipe which can be automatically isolated, neither reactor scram nor reactor isolation may be necessary. Technical Specifications address how long the plant can operate before the isolated system must be restored to service.

2. SYMPTOMS AND AUTOMATIC ACTIONS

The symptoms and automatic actions which are displayed in the control room in the event of a pipe break outside primary containment are listed below. The specific symptoms observed will depend upon the location and size of the break.

2.1 Primary Containment Isolation

There are [7] isolation valve groups, each associated with a system connected to the primary coolant outside of primary containment. One or more of these valve groups will isolate on system signals of high flow, low vessel water level, high radiation, high area temperature, high drywell pressure, low system pressure, etc., which are indicative of a pipe break outside of primary containment. [Utility may provide more specific information on the valve groups and Automatic Actions].

2.2 Other Symptoms and Automatic Actions

2.2.1 Symptoms

~~2.2.1~~ • Excess flow check valves actuation and alarm [ ]

~~2.2.2~~ SBGTS initiation [ ]

~~2.2.3~~ Reactor building isolation [ ]

1402 187

- ~~2.2.4~~ Reactor building high radiation at exhaust vent [ ]
- ~~2.2.5~~ Area radiation monitor alarm [ ]
- ~~2.2.6~~ Decreasing hotwell level or condensate storage tank level
- ~~2.2.7~~ Mismatch between steam and feed flow
- ~~2.2.8~~ Decrease in generator output (MWe)
- ~~2.2.9~~ Increase in reactor power (MWt)
- ~~2.2.10~~ Possible decrease in vessel water level
- ~~2.2.11~~ Possible decrease in vessel pressure, unless MSIV closed, ~~isolate~~ ~~closed,~~ in which case vessel pressure will likely increase to safety/relief valve setpoints

2.2.2 Automatic Actions
- SBGTS initiation [ ]
- Reactor building isolation [ ].

3. IMMEDIATE OPERATOR ACTIONS

3.1 Any Automatic Actions listed in Section 2. above which should have been initiated must be verified, preferably by at least two independent indications, or manually initiated if the Automatic Action did not occur.

* If scram occurs, scram is to be verified by noting that all control rod position lights show rods fully inserted, and that neutron flux indicators show decreasing flux. *

CAUTION #16

If an automatic isolation of a particular system has occurred, do not attempt to de-isolate or restore the system until all available indications have been checked and are found to be normal.

For automatic isolation of a particular valve group, verify all valves in the group are closed by valve position indication and by noting confirming process variables (such as zero flow). When all isolation valves in the suspected broken system are closed, note that area symptoms of high temperature and radiation decrease.

* If there is a failure to completely isolate a suspected broken system, then go to CONTINGENCY #2. *

* If a reactor scram occurs on high drywell pressure, then go to SBA-2 "Pipe Break Inside Primary Containment". *

1402 188

3.2 Continuously monitor vessel water level using all available instrumentation (Repeat 3.3.1 through 3.3.4 in ~~SBA-2~~ SBA-2.)

3.3 Control vessel level with available high pressure systems (feedwater, con-control rod drive pumps, HPCI, RCIC). When the level approaches the high level [8] trip [+58 inches] for feedwater, HPCI, and RCIC, take manual control (if possible) of the high pressure systems to maintain level, and to prevent trips of feedwater, HPCI, and RCIC. Restore to AUTOMATIC/STANDBY mode (if possible) the systems which are not needed to maintain level. Make frequent checks of level when systems are in the MANUAL mode.

* If high pressure systems are unable to maintain level, then go to CONTINGENCY #3. *

CAUTION #9

Do not throttle HPCI and RCIC systems below turbine speeds which yield acceptable continuous operation.

4. SUBSEQUENT OPERATOR ACTIONS

4.1 If the break is successfully isolated, and reactor operation is unaffected, then continue normal operation per the applicable Technical Specification and procedures for equipment out of service.

4.2 If the isolation resulted in a reactor isolation and scram, then follow applicable procedures for scram/isolation recovery [procedure #s].

4.3 If vessel depressurization is necessary, then go to guidelines in SBA-2, Section 4.2.

1402 189

CONTINGENCY #2
FAILURE TO ISOLATE

If the isolation valves fail to isolate the break on either automatic or manual signal, then scram the reactor. Attempt to close the failed isolation valve manually, or to isolate the suspected broken pipe with other valves. Initiate the SBGTS, isolate and evacuate the reactor building. Go to Guideline SBA-3, Section 3.2.

CAUTION #17
Do not dispatch personnel to an area of a suspected pipe break without consideration of adverse environments.

1402 190

CONTINGENCY #3

INABILITY TO MAINTAIN LEVEL WITH HIGH PRESSURE SYSTEMS*

If the operator determines that vessel level cannot be maintained by the high pressure systems, then the operator must manually initiate ADS (operator opens the same valves that the ADS logic would open automatically) when the level reaches level [1]** ~~[1 and after waiting 120 seconds for BWR/3 high pressure systems to regain level]~~.

The operator should make all attempts to start the high pressure systems and regain level before manually initiating ADS.

> **CAUTION #18**
>
> Do not manually initiate ADS unless it is confirmed that the low pressure pumps [LPCS, LPCI] are running.

If the operator is unable to manually initiate ADS, then the operator must manually open other safety/relief valves. As many valves as possible, up to the number used for ADS, should be opened.

After ADS is manually initiated go to Guideline SBA-2, Section 4, "Subsequent Operator Actions".

*includes failure of high pressure systems

** The preset time delay should be included for plants whose ADS level permissive is at the same level as the high-pressure ECCS initiation trips.

1402 191

Conclusions

The guidelines reflect the conclusions of the analysis Section 3.1.1, which are that there is only one immediate operator action needed to maintain core cooling, and it is needed only for a degraded condition. In almost all cases the operator actions are aimed at keeping the vessel from overfilling, or to minimize containment heat loads. The key operator actions are summarized below for breaks inside and outside the primary containment.

For Breaks Inside the Containment:

Immediate Operator Actions

1. Verify automatic actions
2. Take reactor MODE switch out of RUN
3. Monitor water level
4. Control high pressure systems to prevent overfilling the vessel
5. Verify low pressure system injection

Subsequent Operator Actions

1. Control low pressure systems to prevent overfilling the vessel
2. Keep the pool cool by using the main condenser or RHR as heat sinks, or if necessary, depressurize the vessel to prevent later SRV discharge into a hot pool
3. Control containment pressure
4. Follow post-LOCA hydrogen control procedures

For Breaks Outside the Primary Containment:

Immediate Operator Actions are the same as for breaks inside the primary containment except that 1) no action is required regarding the MODE switch, and 2) no low pressure systems are expected to initiate.

Subsequent Operator Actions are either normal operation, isolation recovery, depressurizing the vessel for pool cooling considerations and maintaining pool cooling.

In addition if no high pressure systems are available, then the operator must manually initiate ADS.

These guidelines clearly demonstrate that the small break accident does not present a severe challenge to the BWR and that it can be automatically mitigated. Even for severely degraded conditions (no high pressure systems available) the operator has only to manually initiate ADS to decrease vessel pressure so that the low pressure systems keep the core cooled.

1402 193

3.1.1.3 Justification of Analysis Methods

3.1.1.3.1 Small Breaks Versus Large Breaks

In a BWR, the major difference in the reactor system response to a large break LOCA versus a small break LOCA is the timing of events. No new phenomena are introduced as the break size decreases. This enables the same LOCA computer codes with essentially the same assumptions to be applied for analyzing the full spectrum of break sizes and locations. Table (3.1.1.3 -1) is a qualitative comparison of key LOCA parameters and their relative importance in a small break versus a large break LOCA.

3.1.1.3.2 SAFE Computer Code

3.1.1.3.2.1 Background

The analyses in Section 3.1.1.1.2 have utilized the SAFE computer program to support the development of operator guidelines and emergency procedures for operator training and action during a small break LOCA. The justification for using SAFE and not SAFE/REFLOOD is presented below.

The major difference between the SAFE and REFLOOD codes is the lack of modeling counter current flow limiting (CCFL) effects in the SAFE code. SAFE also has a less detailed modeling of the reactor geometric regions inside the core shroud than the REFLOOD code. These two effects, as shown below, are of secondary importance for developing operator guidelines because of their small effects on reactor response to a small break LOCA. Thus, SAFE by itself is adequate for performing the analyses in Section 3.1.1.1.3. Also, REFLOOD does not model the downcomer region, which is the level monitored by the operator.

3.1.1.3.2.2 Bypass Region

The normal procedure in running SAFE is to lump the mass and volume of the bypass region into Region 2 which also contains the active core. As the void

1402 194