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SUBJECT:
FORWARDING REVISION TO APPLICANT"S REPT SUBMITTED 10/18/78, CONSISTING OF REPT ENTITLED: "A REACTION TO CRACKING OF AUSTENITIC STAINLESS STEEL PIPING IN BOILING WATER REACTORS", AND INCLUDING SUBJECT FACILITY"S SES DESIGN MODIFICATIONS.

PLANT NAME: SUSQUEHANNA - UNIT 1
SUSQUEHANNA - UNIT 2

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BR CHIEF LWR#3 BC**W/ENCL
LIC ASST LWR#3 LA**W/ENCL

INTERNAL:
REG FILE**W/ENCL
NRC PDR**W/ENCL
I & E**W/2 ENCL
OELD**W/ENCL
DIRECTOR DPM**W/ENCL
DEPUTY DIR DPM**W/ENCL
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H SMITH**W/ENCL
DIRECTOR DSS**W/ENCL
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PP&L

TWO NORTH NINTH STREET, ALLENTOWN, PA. 18101 PHONE: (215) 821-5151

SEP 25 1978

Mr. Olan D. Parr, Chief
Light Water Reactors Branch No. 3
Division of Project Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUSQUEHANNA SES
NRC STAFF POSITION ON THE USE
OF AUSTENITIC STAINLESS STEEL
ER 100450 FILES 841-2, 883
PLA-291

Dear Mr. Parr:

Enclosed are 40 copies of a report entitled "A Reaction to Cracking of Austenitic Stainless Steel Piping in Boiling Water Reactors." This report is a revision to a report provided to you on October 18, 1976.

Subsequent to the original issue of this report there have been numerous incidents attributed to Intergrannular Stress Corrosion Cracking (IGSCC). Based on these incidents, PP&L has modified its position on IGSCC, which included additional design changes at SSES. For this reason and to provide PP&L's response to your letter of February 15, 1978, this report has been revised and updated.

Very truly yours,

NW Curtis

N. W. Curtis

WEB:JLI

Enclosure

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PENNSYLVANIA POWER & LIGHT COMPANY

A REACTION TO CRACKING OF AUSTENITIC STAINLESS STEEL PIPING IN BOILING WATER REACTORS (INCLUDES SUSQUEHANNA SES DESIGN MODIFICATIONS)

Earle M. Mead

Earle M. Mead
Project Engineering Manager
Susquehanna SES

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Table and Illustration

1. Introduction

This report originally resulted from an informal telecon between representatives of PP&L and the NRC which occurred in February 1976.

At that time proposed Susquehanna Steam Electric Station (SSES) design changes were briefly discussed and it was agreed that this additional information should be submitted.

Subsequent to the original issue of this report there have been numerous incidents attributed to Intergranular Stress Corrosion Cracking (IGSCC). Based on these incidents, PP&L has modified our position on IGSCC, which included additional design changes at SSES. For the above reason and to provide the NRC with PP&L's position on NUREG-0313, this report has been revised and updated.

2. Problem Statement

From September, 1974 to October, 1976 cracking had been discovered in recirculation bypass loops, core spray lines and control rod drive return lines of 10 GE boiling water reactors. The affected units were:

a) Core spray lines -
Dresden 2, Fukushima 1, and Tsuruga

b) Recirculation bypass lines -
Dresden 2, Quad Cities 1, Quad Cities 2, Peach Bottom 3, Millstone Point 1, Monticello 1, Fukushima 1, Hamaoka 1, Brunswick 2, Hatch 1, and Pilgrim 1.

c) Control rod drive return lines - Tarapur

PP&L believed that sufficient justification existed to recognize the cause as being Intergranular Stress Corrosion Cracking. This report was originally issued on October 12, 1976 and summarized PP&L's concerns as well as modifications that were implemented for SSES.

From October 1976 to the present there have been numerous reports of cracking at other plants which has been attributed to IGSCC. Not only have the above lines been affected, but there are reports of cracking in head vent lines, recirculation riser lines, instrument lines, and also, main recirculation and feedwater lines.

This report has been revised to reflect PP&L's position on IGSCC and the latest modifications which have been made at SSES.

3. Safety Significance

PP&L considers the statement in NUREG-0313, which reads in part, "Although the probability is extremely low that these stress corrosion cracks will propagate far enough to create a significant safety hazard to the public, the presence of such cracks is undesirable" to be an accurate assessment of the safety significance. Beyond that PP&L believes the significance of the failures to relate only to plant reliability.

Based on previous BWR experience, it can be expected that brittle cracking will not occur in austenitic Type 304 stainless steel and that small leaks will be detected visually and/or by leak detection instrumentation if they occur inside the primary containment. The importance of detectability has been recognized and the SSES drywell leak detection system will comply with NRC Regulatory Guide 1.45 (May 1973).

The Inservice Inspection Program at SSES is in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components", 1974 edition, including addenda through Summer 1975, as modified by Appendix III to Winter 1975 addenda, "Ultrasonic Examination Method for Class 1 and Class 2 Piping Systems Made from Ferritic Steels", and IWA-2232 of the Summer 1976 Addenda, using 50% of the reference level as criteria for investigating reflectors.

The ISI Program will be updated as required/allowed by 10CFR50.55a(g). It will also be augmented to comply with the recommendations of NUREG-0313. The degree of augmentation will depend on the outcome of PP&L's detailed evaluation of IGSCC at SSES.

This evaluation will be completed by January 1, 1980 and will address all applicable lines which contain reactor coolant. It will delineate all materials and any fabrication processes which will provide a comprehensive listing of susceptible lines in the as installed condition. The study will then provide an evaluation of all IGSCC countermeasures which are available for use at SSES. The conclusion of the study will be a recommendation of what "course of action" should be taken for each susceptible line, from which countermeasures should be used to how the ISI Program should be augmented.

4. Primary Considerations

4.1 Environment (Coolant Chemistry)

The coolant chemistry in Boiling Water Reactors is established primarily to ensure compatibility with materials used throughout the Nuclear Steam Supply System. Hence, neutral, high-purity water is used and halogens are stringently limited. Limitations are also placed on the silica and copper concentrations to prevent their deposition in the turbine. Dissolved oxygen concentration is not normally controlled by chemical addition or mechanical deaeration.

Without chemical or mechanical control the steady state level of dissolved oxygen at SSES during normal operation will be a maximum of 7.1 ppb. However, during low load or no load conditions the oxygen concentration can approach saturation which, under conditions of standard temperature and pressure, is 8.0 ppm. Under the combined influences of sensitization and high tensile stress this oxygen level is more than sufficient to enable stress corrosion cracking of austenitic stainless steel to occur.

Since, for constant values of sensitization and stress, time-to-failure is directly proportional to dissolved oxygen concentration, low flow and stagnant lines are highly suspect. It would, therefore, be very beneficial to reduce the oxygen level to as low as possible during all phases of plant operation.

4.2 Stress

The design stress levels for Nuclear Steam Supply System (NSSS) Piping are established within the constraints of the ASME Code as well as any loading restrictions which might be imposed by the NSSS vendor. Stress levels sufficient to result in IGSCC generally are not just the result of ordinarily-applied engineering loads or stresses. Rather, they result from the combined effects of all sources of stress and strain: i.e., residuals, thermal, surface, service, etc.

It is very beneficial to minimize the amount of stress acting on the sensitized material. Therefore, the amount of residual and applied stresses should be reduced wherever possible.

4.3 Material

Boiling Water Reactor piping is fabricated from steels which are: corrosion resistant, tough, stable dimensionally, sufficiently strong for anticipated loadings, resistant to radiation damage, resistant to both acidic and basic chemical attack, economical, and anticipated to be available in the foreseeable future. The most prominent materials used are austenitic stainless steels (Types 304 and 316) and carbon steel.

However, it has been determined that the standard grades of 304 and 316 stainless steel with high carbon contents of approximately .06 to .08 percent are the grades which produce the most severe sensitization and thus, the greatest susceptibility to IGSCC. The low carbon ($\leq$ .03 percent carbon) grades of 304 and 316 stainless steel are demonstrating a much greater resistance to IGSCC. These and other alternate materials are undergoing extensive development and evaluation for reducing the probability of IGSCC.

5. SSES Preventive Measures

PP&L efforts have centered on reducing the probability of occurrence of IGSCC for SSES.

Recommended modifications to the existing SSES design were evaluated prior to implementation against the following criteria:

1. Their potential for substantially reducing the probability that IGSCC will occur;

2. Their potential for substantially reducing the time required to detect cracks or leaks resulting from IGSCC;

3. Their potential for creating other problems which would either be as bad as, or worse than, the current problem.

5.1 Environment

Current analyses indicate that among the environment related contributors to the current IGSCC problem in BWR's, the dissolved oxygen concentration of the reactor coolant is probably the most significant. Oxygen levels can be controlled either chemically, mechanically, or operationally.

5.1.1 Chemical Control

Since there is no universal inhibitor for improving BWR water chemistry and since there are limited data concerning the use of oxygen scavengers and neutralizers in BWR's, their use in the primary coolant is not considered at this time. Future developments in this area, however, will be followed.

5.1.2 Mechanical Control

Primary oxygen removal is accomplished in the condenser during normal operation. During this phase the oxygen level is maintained at approximately 7.0 ppb. During any combination of partial load (startup, shutdown, hot standby and some abnormal events) the oxygen level tends to increase toward saturation (approximately 8.0 ppm). There have been two major design changes which PP&L has made to improve the water chemistry at SSES.

5.1.2.1 Control Rod Drive (CRD) Pump Suction Relocation

PP&L previously relocated the CRD pump suction from the condensate storage tank to the condensate makeup/reject line. The purpose of this line is to control primary cycle water inventory by making up from or rejecting to the condensate storage tank. Under steady load conditions this line receives a constant discharge from the condenser due

to primary cycle influent water sources such as the CRD system itself. Hence, locating the CRD pump suction on the makeup/reject line results in utilization of water with the lowest oxygen concentrations available (essentially water with feedwater quality) most of the time.

At the time the above change was made, PP&L believed that this change, in addition to other changes made, was adequate to sufficiently reduce the probability of IGSCC. Since that time, however, PP&L has found that controlling the O_2 concentration as an effective means of controlling IGSCC requires O_2 control during all phases of plant operation, not just normal operation. For this reason, PP&L added a mechanical deaeration system (see section 5.1.2.2).

5.1.2.2 Mechanical Vacuum Deaeration

Based on more recent data, PP&L has taken the steps to add a mechanical vacuum deaeration system at SSES. This O_2 control system will operate during all phases of plant operation except normal operation. It will maintain the O_2 concentration in the primary coolant to less than 250 ppb. This recent change was made in an effort to reduce the corrosive nature of the primary fluid as low as possible. It is PP&L's preference to have the O_2 control system installed and operating prior to plant startup.

5.1.3 Operating Procedures

Lines connected to the reactor vessel which are normally stagnant or experience low flow conditions may accumulate dissolved oxygen concentrations which are high relative to general reactor water. Startup, Shutdown, Hot Standby and abnormal events are of particular significance.

To the extent practical, procedures will be developed which will minimize dissolved oxygen concentrations in stagnant or low flow lines and/or reduce the total time of stagnant conditions.

The water quality sampling system has been upgraded in order to alert the plant operators of adverse water conditions conducive to IGSCC. It includes continuous monitoring of feedwater and reactor water for dissolved oxygen concentration, conductivity and pH and continuous monitoring of the CRD system water for dissolved oxygen concentration and conductivity. The sampling system automatically alarms when water quality conditions considered to be adverse to BWR operation are reached.

Procedures will be developed which will minimize excessive oxygen concentrations in the primary cycle and to enable plant operators to take immediate action to protect the plant from prolonged operation with adverse water quality conditions.

5.2 Stress

Stress alone is not particularly significant so far as the overall corrosion of metals is concerned. When combined with a corrosive environment, however, the application of sufficient tensile stress in susceptible materials can lead to stress corrosion cracking. A reduction in total tensile stress in lines considered susceptible to IGSCC could therefore be considered beneficial.

In an attempt to reduce overall tensile stress, piping located inside containment and connected directly to either the Reactor Pressure Vessel (RPV) or the Reactor Recirculation System was reviewed to determine if design and/or fabricating contributions to tensile stress levels could be reduced.

5.2.1 Design Stresses

The combined effects of service, internal pressure, deadweight and thermal stresses were reviewed and all piping systems were confirmed to have layouts which limited their contributions to total stress to a level considered to be as low as reasonably achievable.

Recognizing the particular susceptibility of the Core Spray System injection lines, alternate routings were chosen in order that the thermal stress component of total stress is reduced by 25%.

5.2.2 Fabrication Stresses

The difficulty in assuring compliance under all shop and field fabricating conditions, limits the effectiveness of procedures which might be developed in this area. However, since stress levels in non-stress relieved austenitic stainless steel piping can equal or exceed yield, any procedures which might significantly reduce fit-up, initial fabrication, or welding-induced stresses cannot be overlooked.

5.2.2.1 Fit-up

Code tolerance for alignment are complied with to assure minimum stress from misalignment and minimum degradation of fatigue resistance.

5.2.2.2 Initial Fabrication (shop)

The pipe material is purchased in the solution annealed condition. Normally, spool pieces are not solution annealed due to the difficulty of maintaining desired dimensions.

5.2.2.3 Welding-Induced Stress

PP&L recognizes that when austenitic stainless steels are welded, some level of residual stress and sensitization is present. A compromise between heat input control and the resulting cooling rate must be achieved in order that acceptable levels of residual stress and sensitization can be achieved without sacrificing good penetration and fusion.

Unfortunately, precise quantitative values of heat input, cooling rate, etc., which will insure consistently good quality welds resistant to IGSCC are not available. Therefore, PP&L relies on past industrial experience for guidance.

PP&L has adopted the following measures for field welding the applicable lines. These measures help reduce welding-induced stresses, without creating additional problems, to a level as low as can be expected using normal welding practices.

5.2:2.3.1 Heat Input

a. No preheat (in excess of the acceptable working range of 60°F to 150°F).

b. Interpass temperature limited to 350°F.

c. Block welding prohibited.

d. Electrode size limited to 5/32" Max. for SMAW and 1/8" Max. for GTAW which effectively limits the heat input.

5.2.2.3.2 Joint Design

a. The root is made with GTAW utilizing hand fed filler wire or a consumable insert to insure complete penetration and good fusion.

b. The extended-land joint design has no inherent problems with lack of penetration, lack of fusion or excessive residual stress.

c. An inert gas purge is used prior to welding and inert gas backing is used during the welding of the first passes to insure a good root contour minimizing the occurrence of any crevices which might lead to corrosion problems.

d. A smooth finish contour is specified (i.e., no excessive undercut, excessive reinforcement, coarse ripples, etc.) to reduce the occurrence of "notches" which can detrimentally affect fatigue strength or corrosion resistance.

5.2.2.3.3 Filler Metal

To minimize microfissuring and sensitization problems, 308L filler metal or 309 and 309L filler metal is specified with minimum delta ferrite contents of 8 percent and 5 percent respectively.

5.2.2.3.4 Cleanliness

To prevent contamination of the joint:

a. Grease, oil and other contaminants are removed from the joint and the filler metal prior to making the weld.

b. Only marking crayons, chalk, ink and temperature indicating crayons which are certified to be low in halogen and sulfur content are used.

c. Only cleaning solvents which are not harmful to austenitic stainless steel are used.

d. Stainless steel wire brushes are used.

e. Grinding wheels used on other materials are not used on stainless steel.

f. Grinding wheels are not used on I.D. pipe surfaces. If cleaning is necessary, flapper wheels shall be used.

The existing methods and procedures for Quality Control/ Quality Assurance of the above are adequate to insure that these provisions are followed and that the results will be consistent with what was specified. Restrictions consistent with those above apply equally to shop and field subcontract welding.

5.2.3 Methods of Stress Reduction

Due to continued reports of IGSCC since PP&L first formed a position on the subject, PP&L has stepped up its monitoring of the problem and its possible countermeasures. Those countermeasures that are being investigated/evaluated which deal with stress reduction are Solution Heat Treatment (SHT), Heat Sink Welding (HSW), and Induction Heating Stress Improvement (IHSI).

5.2.3.1 Solution Heat Treatment

This IGSCC countermeasure stress relieves shop welds before the sections of pipe are shipped to the field for installation. This method can only be used on shop welds, and then, only when the pipes have not been installed.

For SSES most of the target lines for which no other countermeasures (i.e., material changes) have been taken, have already been installed. However, the shop welds on the recirculation jet pump risers underwent SHT because PP&L believed these lines to be extremely susceptible to IGSCC. The field weld ends of the risers were also corrosion resistant clad. This process will be discussed in a later section.

5.2.3.2 Heat Sink Welding

This IGSCC countermeasure requires cooling the ID of the pipe with cooling water after the root pass of the weld has been completed. This process causes the resultant residual stresses on the ID of the pipe to be compressive rather than tensile as would be found with normal welding practices. Resultant compressive stresses prevent IGSCC.

This countermeasure has not been used at SSES. However, Bechtel is presently performing a feasibility evaluation on the use of HSW for selected lines at SSES.

5.2.3.3 Induction Heating Stress Improvement

This IGSCC countermeasure is used after the field welds have been completed. The process involves heating the O.D. of the pipe with an induction coil while cooling the I.D. with cooling water. This process causes the resultant stresses on the I.D. of the pipe to be compressive rather than tensile, thus preventing IGSCC.

This process has not been used at SSES. Presently GE is in the process of developing/qualifying this procedure for use on BWR's in the United States (Reportedly the Japanese have used this procedure successfully on their nuclear power plants.). PP&L intends to track the progress of GE and use the procedure on susceptible lines if and when the procedure is determined to be feasible.

5.3 Material

Due to the restrictions of coolant chemistry and total tensile stress levels, the use of substitute materials which are less susceptible to IGSCC were considered. The lack of significant operating data for materials other than carbon steel or Type 304 and Type 316 stainless steels limits the options, however.

During the design of the plant, attention was given to minimizing problems related to gross corrosion. Stainless steel was chosen for Core Spray lines inside containment, condenser and feedwater heater tubes, and ASTM A155 Grade KC 70, Class 1 feedwater pipe. PP&L is, therefore, unwilling to use carbon steel as an IGSCC fix.

The principal drawback to the continued use of Type 304 and Type 316 stainless steel for NSSS piping is their susceptibility to IGSCC. PP&L believes this susceptibility is related to sensitization which occurs adjacent to a weld in the heat-affected zone. Sensitization is a temperature dependent metallurgical phenomenon which results in the formation of chromium carbide at grain boundaries located in the heat-affected zone of a weld. Therefore, it was logical to limit the carbon content of susceptible lines.

Originally, the history of the IGSCC problem formed the basis of the assumption that the combination of residual stress and sensitization was insufficient to result in a high probability of failure due to IGSCC for lines in the reactor coolant pressure boundary larger than 12" diameter NPS. The focus for possible material substitution was, therefore, on those lines which were less than or equal to 12" diameter NPS. Any such substitutions would apply equally to pipe fittings. However, valves and containment penetration flued heads are not included as they are of sufficient mass to be substantially less susceptible to IGSCC.

Based on the above assumption, Type 304L stainless steel was used for all stainless piping within the reactor coolant pressure boundary which is 4" diameter NPS or smaller with a supplemental requirement of 0.030 percent maximum carbon (with the exception of the Recirculation System Discharge Gate Valve Bypass Line). Stainless piping located within the reactor coolant pressure boundary which is greater than 4" but less than 12" diameter NPS will be Type 304 stainless steel with a maximum carbon content of 0.030 percent. These two materials are virtually identical metallurgically but PP&L is unwilling to sacrifice the mechanical properties of 304 for certain piping systems.

Table 1 identifies piping for which a change in material was justified, the material previously specified, and the replacement material chosen to mitigate the probability of IGSCC.

Since the time the above material changes were made, additional incidents of IGSCC have shown that the assumption that only those lines which are 12" diameter NPS or less are susceptible to IGSCC is incorrect. Therefore, all lines must be considered when attempting to eliminate or reduce IGSCC.

In addition to simple material replacement, the other "material" related IGSCC countermeasure which can be evaluated is Corrosion Resistant Cladding (CRC). This countermeasure combines cladding the field welded pipe ends with a highly corrosion resistant metal with solution annealing which effectively provides a corrosion resistant barrier between the heat affected base metal and the oxygenated reactor coolant (corrosive fluid).

As discussed in Section 5.3.4 of this report, PP&L utilized CRC on the recirculation jet pump risers.

Due to their particular significance with regard to the current problem, the Core Spray, Reactor Recirculation System Discharge Gate Valve Bypass Line, Control Rod Drive Return Line, and Recirculation Riser Pipes are discussed below.

5.3.1 Core Spray System

That portion of the core spray system which is located within the primary containment will, for Susquehanna SES, be made from 12" diameter NPS, Type 304 Stainless Steel Pipe with supplemental maximum carbon limitation of 0.030 percent. Pipe and fittings will be handled similarly.

5.3.2 Reactor Recirculation System Discharge Gate Valve Bypass Line

From an operational standpoint PP&L does not wish to delete this line.

It is considered important from the following standpoints:

1. It provides a means of preheating an idle recirculation loop.

2. It reduces thermal shock seen by the components of an idle loop.

3. It provides pressure equalization on both sides of the discharge gate valve to assure proper venting and closure of the valve.

4. It eliminates cutting and wire drawing of the discharge gate valve seat.

The 4" diameter NPS line will be fabricated from Type 304 stainless steel with a supplemental maximum carbon limitation of 0.030 percent. This material choice results from the desire to limit the probability of IGSCC while retaining the mechanical properties of and the existing stress analysis for Type 304 stainless steel. Pipe and fittings will be handled similarly.

5.3.3 Control Rod Drive Return Line

This 3" diameter line was changed from 304SS to 304L SS which, it was believed, would solve the problem of IGSCC. Subsequent to this change there were numerous reported incidents of cracking in the CRD Return Line nozzle. These incidents of cracking were attributed to excessive thermal gradients across the nozzle rather than IGSCC. General Electric's recommendation was to delete the return line and make other changes to the system to maintain the system design function. PP&L concurred with GE's recommendation and deleted the return line. This action (1) eliminated the problem of nozzle cracking due to thermal gradients and (2) eliminated the possibility of pipe cracking due to IGSCC.

5.3.4 Recirculation Riser Pipes

The 10" recirculation riser pipes leading from the recirculation header to the jet pumps have recently experienced IGSCC at other operating plants. The cracks have been formed in the heat affected zones of the thermal sleeve to safe end attachment welds. The pipes have been fabricated from 304 stainless steel. The safe ends are Imonel 600, and the nozzles are carbon steel clad with stainless steel.

PP&L has made the following changes which will minimize the possibility of these pipes cracking due to IGSCC of Susquehanna SES.

1. The pipe to safe end and pipe to tee welds will have their ID's clad with 308L weld material in the heat affected area prior to welding.

2. The riser pipes will be solution heat treated to eliminate residual stresses from the elbow to pipe shop welds, and the CRC process.

3. These welds will then be field welded using 308L welding rods.

This process will prevent 304 stainless steel in the heat affected area from coming in contact with the process fluid.

6. References

Source	Document	Date
GE	NEDO-21000	July, 1975
NRC	NUREG 75/067	October, 1975
ASTM	"Stress Corrosion Cracking of Metals - A State of the Art"	October, 1971
NATO	"The Theory of Stress Corrosion Cracking in Alloys"	October, 1971
NACE	"Fundamental Aspects of Stress Corrosion Cracking"	September, 1967
United States Senate	Joint Hearing Concerning "Nuclear Regulatory Commission Action Requiring Safety Inspections Which Resulted in Shutdown of Certain Nuclear Power Plants"	February, 1975

SUSQUEHANNA STEAM ELECTRIC STATION

TABLE 1

MATERIAL CHANGES

Pipe Description	Size (NPS)	Previous Material	New Material
Head Spray	6"	Type 304SS	Carbon-Limited Type 304SS
Core Spray Influent	12"	"	"
Control Rod Drive Hydraulic Return	3"	"	CRD Return Line Has Been Deleted
Standby Liquid Control	1-1/2"	"	"
Reactor Water Cleanup Effluent	4"	Type 304SS to first valve, then Carbon Steel	Type 304LSS to first valve, then to Carbon Steel
Instrument Piping	1", 2" & 4"	Type 304SS	Type 304L SS
Vent, Drain, and Test Connections Shown on Figure 1	1"	Type 304SS	Type 304L SS
Recirculation System Bypass	4"	Type 304SS	Carbon-Limited Type 304SS
Bottom Drain	4"	Type 304SS	Type 304L SS

TFO:bah

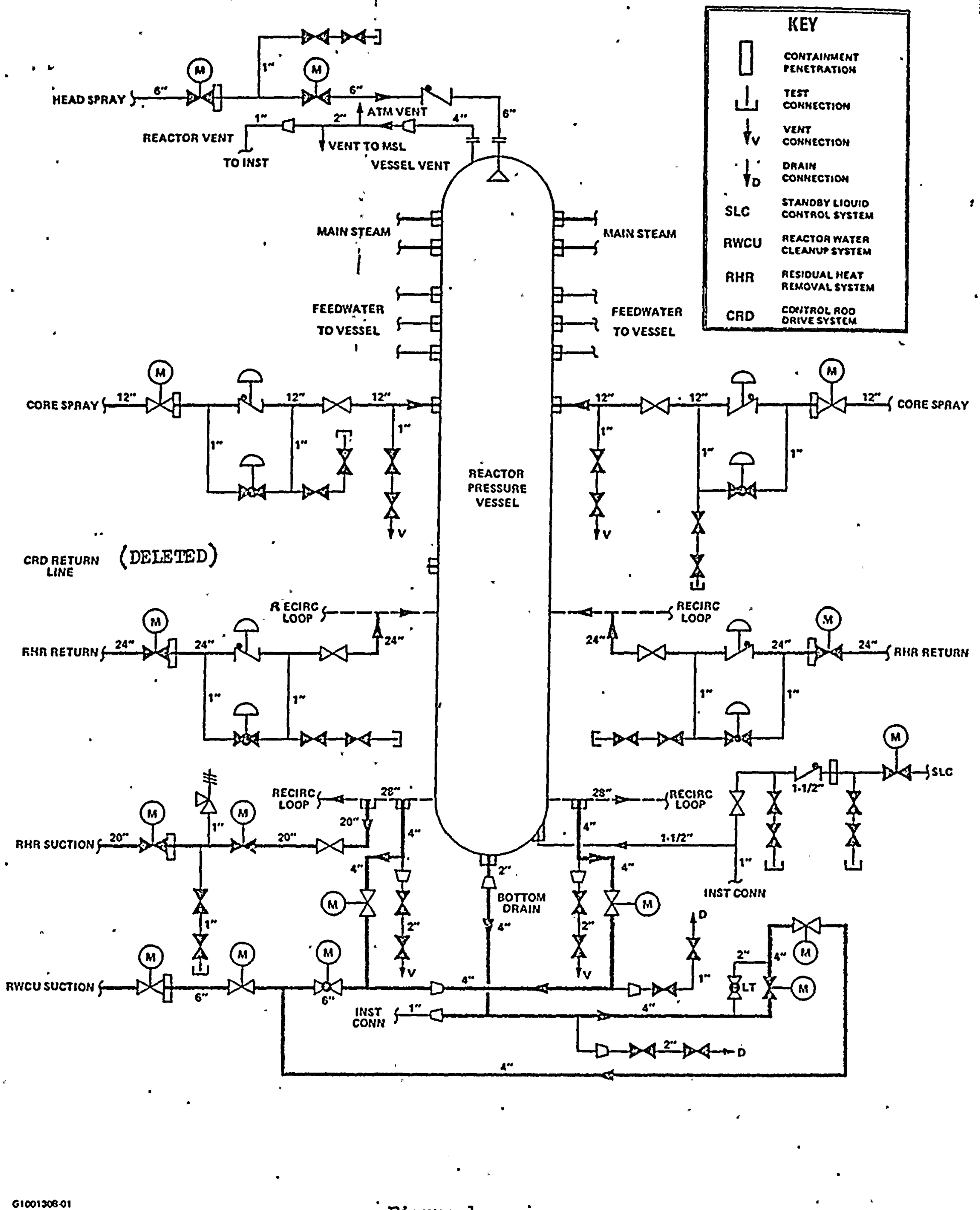
KEY
CONTAINMENT PENETRATION
TEST CONNECTION
VENT CONNECTION
DRAIN CONNECTION
SLC STANDBY LIQUID CONTROL SYSTEM
RWCU REACTOR WATER CLEANUP SYSTEM
RHR RESIDUAL HEAT REMOVAL SYSTEM
CRD CONTROL ROD DRIVE SYSTEM
HEAD SPRAY
REACTOR VENT
TO INST
ATM VENT
VENT TO MSL
VESSEL VENT
MAIN STEAM
MAIN STEAM
FEEDWATER TO VESSEL
FEEDWATER TO VESSEL
CORE SPRAY
CORE SPRAY
REACTOR PRESSURE VESSEL
CRD RETURN LINE
(DELETED)
RECIRC LOOP
RECIRC LOOP
RHR RETURN
RHR RETURN
RECIRC LOOP
RECIRC LOOP
SLC
RHR SUCTION
INST CONN
BOTTOM DRAIN
RWCU SUCTION
INST CONN
LT
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Figure 1