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Your ref: Docket No. 52-006
Our ref: DCP/NRC1636

October 13, 2003

SUBJECT: Transmittal of Responses to AP1000 DSER Open Items

This letter transmits the Westinghouse responses to Open Items in the AP1000 Design Safety Evaluation Report (DSER). A list of the DSER Open Item responses transmitted with this letter is Attachment 1. The proprietary responses are transmitted as Attachment 2. The non-proprietary responses are provided as Attachment 3 to this letter.

The Westinghouse Electric Company Copyright Notice, Proprietary Information Notice, Application for Withholding, and Affidavit are also enclosed with this submittal letter as Enclosure 1. Attachment 2 contains Westinghouse proprietary information consisting of trade secrets, commercial information or financial information which we consider privileged or confidential pursuant to 10 CFR 2.790. Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosures.

This material is for your internal use only and may be used for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Commission, the Office of Nuclear Reactor Regulation, the Office of Nuclear Regulatory Research and the necessary subcontractors that have signed a proprietary non-disclosure agreement with Westinghouse without the express written approval of Westinghouse.

D063

October 13, 2003

Correspondence with respect to the application for withholding should reference AW-03-1720, and should be addressed to Hank A. Sepp, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company, P.O. Box 355, Pittsburgh, Pennsylvania, 15230-0355.

Please contact me at 412-374-5355 if you have any questions concerning this submittal.

Very truly yours,

M. M. Corletti
Passive Plant Projects & Development
AP600 & AP1000 Projects

/Enclosure

1. Westinghouse Electric Company Copyright Notice, Proprietary Information Notice, Application for Withholding, and Affidavit AW-03-1720.

/Attachments

1. List of the AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Responses transmitted with letter DCP/NRC1636
2. Proprietary AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Responses dated October 13, 2003
3. Non-Proprietary AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Responses dated October 13, 2003

DCP/NRC1636
Docket No. 52-006

October 13, 2003

Enclosure 1

Westinghouse Electric Company
Application for Withholding and Affidavit

Westinghouse Electric Company
Nuclear Power Plants
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

October 13, 2003

AW-03-1720

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Mr. John Segala

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

SUBJECT: Transmittal of Westinghouse Proprietary Class 2 Documents Related to AP1000 Design Certification Review Draft Safety Evaluation Report (DSER) Open Item Response

Dear Mr. Segala:

The application for withholding is submitted by Westinghouse Electric Company, LLC ("Westinghouse") pursuant to the provisions of paragraph (b)(1) of Section 2.790 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject documents. In conformance with 10 CFR Section 2.790, Affidavit AW-03-1720 accompanies this application for withholding setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.790 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-03-1720 and should be addressed to the undersigned.

Very truly yours,

M. M. Corletti
Passive Plant Projects & Development
AP600 & AP1000 Projects

/Enclosures

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AW-03-1720

COMMONWEALTH OF PENNSYLVANIA:

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COUNTY OF ALLEGHENY:

Before me, the undersigned authority, personally appeared James W. Winters, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company, LLC ("Westinghouse"), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief.

PATRICIA L. CROWN COMMONWEALTH OF PENNSYLVANIA NOTARY PUBLIC

James W. Winters, Manager
Passive Plant Projects & Development
Nuclear Power Plants Business Unit

Sworn to and subscribed
before me this 13th day
of October, 2003

Notarial Seal
Patricia L. Crown, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires Feb. 7, 2005
Member, Pennsylvania Association of Notaries

Patricia L. Crown

Notary Public

(1) I am Manager, Passive Plant Projects & Development, of the Westinghouse Electric Company LLC ("Westinghouse"), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rulemaking proceedings, and am authorized to apply for its withholding on behalf of the Westinghouse Electric Company, LLC.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.790 of the Commission's regulations and in conjunction with the Westinghouse application for withholding accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by the Westinghouse Electric Company, LLC in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information which is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.790, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in Attachment 2 as Proprietary Class 2 in the Westinghouse Electric Co., LLC document: (1) "AP1000 Design Certification Review, Draft Safety Evaluation Report Open Item Response."

This information is being transmitted by Westinghouse's letter and Application for Withholding Proprietary Information from Public Disclosure, being transmitted by Westinghouse Electric Company letter AW-03-1720 to the Document Control Desk, Attention: John Segala, CIPM/NRLPO, MS O-4D9A.

This information is part of that which will enable Westinghouse to:

(a) Provide documentation supporting determination of APP-GW-GL-700, "AP1000 Design Control Document," analysis on a plant specific basis

(b) Provide the applicable engineering evaluation which establishes the Tier 2 requirements as identified in APP-GW-GL-700.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of similar information to its customers for purposes of meeting NRC requirements for Licensing Documentation.

(b) Westinghouse can sell support and defense of AP1000 Design Certification.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar methodologies and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended for performing and analyzing tests.

Further the deponent sayeth not.

DCP/NRC1636
Docket No. 52-006

October 13, 2003

Copyright Notice

October 13, 2003

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.790 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.790(b)(1).

DCP/NRC1636
Docket No. 52-006

October 13, 2003

Attachment 1

List of

Proprietary and Non-Proprietary Responses

Table 1 **"List of Westinghouse's Responses to DSER Open Items Transmitted in DCP/NRC1636"**	
3.6.3.4-2 Addendum 1 Revision 1 15.2.7-1 Item 7 Revision 1 *21.5-2P Item 28 Revision 1 21.5-2 Item 28 Revision 1 *Proprietary	

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 3.6.3.4-2 Addendum 1 Revision 1

Original RAI Number(s): 251.004

Summary of Issue:

In RAI 251.005, the staff requested that the applicant provide values of crack morphology parameters, e.g., surface roughness, number of 45 degree and 90 degree turns, etc., that were used in generating the BACs for LBB. The NRC staff also asked for a comparative study, using the values of crack morphology parameters associated with transgranular stress corrosion cracking (TGSCC). This information and the study were requested to evaluate the BACs and to understand the sensitivity of the AP1000 LBB analyses to a crack morphology similar to PWSCC. In its response to RAI 251.005, the applicant provided the values of crack morphology parameters used in generating the BACs. However, since chlorides will be controlled at minimum levels in the AP1000 LBB candidate piping systems water environment and the hydrogen overpressure will keep the oxygen levels to near zero, the applicant discounted the possibility of TGSCC and considered the comparative study using the crack morphology parameters associated with TGSCC not necessary. The applicant's argument does not address the intent of RAI 251.005. The NRC staff performed an independent sensitivity study to assess the impact on the BACs due to a consideration of a TGSCC type of crack in the LBB analysis as a surrogate for PWSCC. The NRC staff's independent sensitivity study shows that the BACs might not be easily met by the most limiting piping. DCD Tier 2 Appendix 3B.3.3.4 does not rule out the possibility of a LBB candidate piping system not meeting the BAC limit either, as evidenced by the statement: "[i]f the point falls above the bounding analysis curve, the leak-before-break analysis criteria are not satisfied and the pipe layout or support configuration needs to be revised to meet the leak-before-break bounding analysis."

The information provided by the applicant has not been sufficient to address the staff position in SECY-93-087, discussed in DSER Section 3.6.3.1, on demonstrating that adequate margins on leakage, loads, and flaw sizes are available for AP1000 LBB candidate piping systems. In addition, the information provided is not sufficient to understand the degree to which PWSCC may affect LBB margins. Therefore, the staff is evaluating the appropriate analyses the applicant should perform to resolve these issues. The staff expects to issue a supplemental DSER on LBB. This is Open Item 3.6.3.4-2.

Westinghouse Response:

Westinghouse provided a response to this DSER Open Item in Westinghouse letter DCP/NRC1611 dated 8/13/2003. This addendum provides our assessment of the AP1000 piping systems designated as Leak-Before-Break (LBB), and provides the basis for the staff to complete the FSER on LBB.

AP1000 Evaluation of Candidate LBB Piping Systems

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42. Bounding Analysis Curve – ADS Stage 4 - 14", 120F – Bounding Seismic Increase Factor

1.0 INTRODUCTION

For AP1000 piping design, Westinghouse proposes to use a DAC/ITAAC approach similar to what was used for previous Design Certifications. Following the proposed DAC/ITAAC approach, the staff reviews and approves the methodology, design criteria, and analysis acceptance criteria that would be used to perform the detailed piping design. The methods, design criteria, and analysis acceptance criteria are referenced as Tier 2* information in the AP1000 Design Control Document (DCD). Westinghouse has also committed that a COL applicant would be required to complete the piping analyses for the piping systems designated as Leak-Before-Break (LBB) lines at the time of a COL application. These analyses would be completed as a condition of the COL. Similar to the other certified designs, the final piping design and analysis for the as-built piping are subject to ITAAC verification.

In the AP1000 Draft Safety Evaluation Report, the staff has indicated that additional information should be provided by Westinghouse to provide high confidence that the piping systems designated as LBB will be able to meet the LBB acceptance criteria at the time of a COL. To accomplish this, the staff requested Westinghouse to complete a piping stress analysis of one LBB candidate piping system and demonstrate that the piping stress analysis results are within the limits of the AP1000 LBB Bounding Analysis Curves included in the DCD. Westinghouse presented analysis results of the direct vessel injection line A (DVI-A) subsystem previously to the staff and these results are included in this report. Westinghouse plans to complete this analysis with the final AP1000 seismic response spectra included in the DCD and will provide updated results to the staff when they are available. The technical basis for the determination that the DVI-A subsystem represents a limiting analysis for AP1000 LBB is provided in this addendum.

The staff also indicated that Westinghouse should perform a qualitative assessment of other LBB candidate subsystems to demonstrate feasibility to qualify the lines for LBB, and provide reasonable assurance that the other LBB candidate subsystems will be within their respective BACs. This report describes the feasibility assessment for application of the LBB methodology to the high energy piping systems in the AP1000. The LBB feasibility assessment is based on comparisons between the AP1000 piping and the corresponding piping in the AP600 standard plant. Westinghouse completed the LBB analysis for the AP600 piping systems designated as LBB in support of AP600 design Certification. An assessment of the feasibility of successfully qualifying the AP1000 LBB lines that have not been analyzed is performed by applying correction factors to the piping analysis results for the AP600 plant. The AP600 lines are generally similar to the AP1000 plant lines. Factors are developed that account for the AP1000 seismic floor response spectra, the changes in the elevations of the pipe/equipment supports, and the changes in pipe diameter. Section 2 describes the assessment methodology. Section 3 discusses the results for each candidate LBB piping line. A brief summary is given in Section 5.

The majority of AP1000 piping systems that are identified as candidate LBB systems have been successfully licensed as LBB systems for operating plants. These include such systems

as the reactor coolant loop, pressurizer surge line, residual heat removal systems, and safety injection systems. Additionally, the main steam lines are also identified as LBB candidate systems and these lines have also been qualified as LBB lines for both the AP600 and System 80+ designs.

The AP1000 employs passive safety systems that are critical in providing for emergency core cooling. Of these passive systems, the Direct Vessel Injection (DVI) and the 4th Stage Autromatic Depressurization System (ADS) are considered to be the most important portions of the passive safety system features in the mitigation of loss of coolant accidents. Therefore it is desirable that the layout of these piping systems not be significantly changed to accommodate qualification of the lines for LBB. Therefore, in order to provide further confidence of the feasibility of these lines to be qualified for LBB, additional evaluations have been performed. As previously stated, Westinghouse performed a complete stress analysis of the DVI-A with the final AP1000 seismic response spectra included in the DCD. The results of the DVI-A evaluations are provided in Section 2.5 and Table 3. For the evaluation of the 4th stage ADS piping, a bounding seismic increase factor is identified for the applicable seismic response spectra based on a comparison of seismic accelerations for each corresponding frequency. This bounding approach is more conservative than the methodology used for the other lines, and provides an additional level of confidence as to the feasibility of qualifying these critical piping systems for LBB.

2.0 ASSESSMENT METHODOLOGY

The candidate pipe lines for Leak-Before-Break for the AP1000 plant are listed in Table 1. The AP1000 pipe lines are generally similar to the corresponding AP600 lines. The lines are the same lines that were identified and analyzed for LBB for the AP600. A comparison of the AP1000 and AP600 LBB pipe lines was provided to the NRC in Westinghouse letter DCP/NRC1516, dated August 5th, 2002. In addition, the NRC staff visited Westinghouse and reviewed the detailed AP1000 piping arrangement including the three dimensional electronic model. Several of the AP1000 lines have larger pipe diameters. The normal operating temperatures and pressures are similar. The in-structure seismic response spectra for the AP1000 plant are different from the AP600 plant primarily because of the taller shield building and the taller walls for the steam generator and pressurizer subcompartments. The AP1000 spectra used are based on the most recent seismic analysis documented in Section 3.7 of Revision 6 to the DCD. The seismic analysis includes the impact of reduced shear wall stiffness as requested in DSER open item 3.7.2.3-1. The Bounding Analysis Curves (BACs) in the AP1000 Design Control Document are based on a reliable leak detection capability of 0.5 gallons per minute and ASME Code minimum values for material strength. DCD Subsection 5.2.5 provides a description of the leak detection monitors for AP1000. RCS leakage detection instrumentation is also addressed in Technical Specification 3.4.10. The Bounding Analysis Curve for the Main Steam line incorporates the material tensile and fracture toughness properties that were measured from material testing for the design of the AP600 plant. The following methodology addresses the differences between the AP1000 and the AP600 and uses the estimated stresses in the piping system in combination with the corresponding AP1000 LBB Bounding Analysis Curve to evaluate the feasibility of LBB for each pipe line.

TABLE 1
CANDIDATE LBB PIPE LINES

LINE	DESCRIPTION (AP1000)
1A	Primary Loop Hot Leg - 31"
1B	Primary Loop Cold Leg - 22"
2	Pressurizer Surgeline - 18"
3A	ADS Stage 2,3 - 14"
3B	ADS Stage 2,3 - 8"
3C	Pressurizer Safety - 6"
4A	ADS Stage 4 East - 18"
4B	ADS Stage 4 East - 14" (610F)
4C	ADS Stage 4 East - 14" (120F)
5A	ADS Stage 4 West - 18"
5B	ADS Stage 4 West - 14" (610F)
5C	ADS Stage 4 West - 14" (120F)
6A	Normal RHR Suction - 20"
6B	Normal RHR Suction - 12"
6C	Normal RHR Suction - 10"
7	Passive RHR Return - 14"
8A	DVI-A - 8" 316 (537F)
8B	DVI-A - 8" 316 (120F)
8C	DVI-A - 8" 304
8D	DVI-A - 8" schedule 40S
8E	DVI-A RNS - 6"
8F	DVI-A PXS - 8"
9A	DVI-B - 8" 316 (537F)
9B	DVI-B - 8" 316 (120F)
9C	DVI-B - 8" 304
9D	DVI-B - 8" schedule 40S
9E	DVI-B RNS - 6"
9F	DVI-B PXS - 8"
10	CMT-A (West) -8"
11	CMT-B (East) -8"
12	Main Steam - A (West) -38"
13	Main Steam - B (East) - 38"

2.1 SEISMIC PIPE STRESSES

The AP1000 pipe/equipment support elevations are used to select the AP1000 response spectra curves. These elevations are generally higher than the corresponding elevations for the AP600 plant. The AP600 pipe lines have been analyzed for seismic loading using the envelope response spectra methodology or the time history methodology (for the reactor coolant loop hot leg and cold leg lines). The AP600 seismic analysis models include the equipment and equipment supports. The seismic stresses for the AP1000 pipe lines are estimated by applying a seismic multiplication factor to the AP600 seismic stress. This multiplication factor is based on the horizontal in-structure seismic response spectra at the elevation of the highest pipe line support or equipment support for each particular pipe line model. The vertical response spectra are generally lower and have less of an effect on the seismic pipe stress. For each horizontal direction the peak of the AP1000 spectrum is divided by the peak of the AP600 spectrum. These ratios are shown on the seismic response spectrum curves in Figures 1 through 8. The largest of these two ratios from the two horizontal seismic response spectra is then used as the seismic multiplication factor. The factors are summarized in Table 2. The estimated seismic stress is then modified to account for the changes in pipe diameter as required. This is described in Section 2.2.

Table 2
SEISMIC MULTIPLICATION FACTORS

LINE	DESCRIPTION (AP1000)	MAXIMUM SEISMIC ELEVATION (FT) AP600	AP1000	AP1000 SEISMIC FACTOR
1A	Primary Loop Hot Leg - 31"	135	153	1.74
1B	Primary Loop Cold Leg - 22"	135	153	1.74
2	Pressurizer Surgeline - 18"	158	169	2.71
2	Pressurizer Surgeline - 18"	158	multi-point	1.36
3A	ADS Stage 2,3 - 14"	158	169	2.71
3B	ADS Stage 2,3 - 8"	158	169	2.71
3C	Pressurizer Safety - 6"	158	169	2.71
4A	ADS Stage 4 East - 18"	135	153	1.42
4B	ADS Stage 4 East - 14" (610F)	135	153	1.42
4C	ADS Stage 4 East - 14" (120F)	135	153	1.42
5A	ADS Stage 4 West - 18"	135	153	1.74
5B	ADS Stage 4 West - 14" (610F)	135	153	1.74
5C	ADS Stage 4 West - 14" (120F)	135	153	1.74
6A	Normal RHR Suction - 20"	135	153	1.42
6B	Normal RHR Suction - 12"	135	153	1.42
6C	Normal RHR Suction - 10"	135	153	1.42
7	Passive RHR Return - 14"	135	153	1.74
8A	DVI-A - 8" 316 (537F)	107	107	1.28 (1)
8B	DVI-A - 8" 316 (120F)	107	107	1.28 (1)
8C	DVI-A - 8" 304	107	107	1.28 (1)
8D	DVI-A - 8" schedule 40S	107	107	1.28 (1)
8E	RNS - 6"	107	107	1.28 (1)
8F	PXS - 8"	107	107	1.28 (1)
9A	DVI-B - 8" 316 (537F)	107	107	1.28
9B	DVI-B - 8" 316 (120F)	107	107	1.28
9C	DVI-B - 8" 304	107	107	1.28
9D	DVI-B - 8" schedule 40S	107	107	1.28
9E	RNS - 6"	107	107	1.28
9F	PXS - 8"	107	107	1.28
10	CMT-A (West) -8"	135	153	1.74
11	CMT-B (East) -8"	135	153	1.42
12	Main Steam - A (West) -38"	135	153	1.74
13	Main Steam - B (East) - 38"	135	153	1.74 (2)

Notes (1) Results are provided for DVI-A based piping stress analysis per Section 2.5.

(2) Assessment of the Main Steam – B (East) system is based on the results from the Main Steam – A (West) evaluation due to the similarity of the two systems.

2.2 PIPE LINE DIAMETER AFFECTS

Several of the AP1000 pipe lines have larger pipe diameters than the corresponding AP600 pipe line. The larger diameter results in a stiffer line for thermal expansion loads and a higher section modulus. For an applied thermal displacement, the moment in the pipe is proportional to moment of inertia and therefore proportional to the diameter cubed. Since the pipe section modulus is proportional to the diameter squared, the thermal stress in the pipe (stress equals moment/section modulus) is proportional to the pipe diameter. The diameter ratio approach is valid when the ratio of the pipe diameter to wall thickness remains the same while the diameter is increased. The thermal stress is caused by restraining the thermal growth of the pipe. The thermal stress is equal to the moment divided by the section modulus. The moment in the pipe is approximately proportional to the stiffness of the pipe which is represented by the moment of inertia. The piping system consists of straight section and elbows. The moment of inertia for an elbow can be taken as the moment of inertia of the straight pipe divided by the elbow flexibility factor. The affect on the thermal stresses in the pipe due to increasing the pipe diameter can be assessed by calculating the following ratios: (moment of inertia of pipe)/(section modulus of pipe), and (moment of inertia of bend/section modulus of bend). Based on these ratios, the following table shows that the thermal stress increases approximately in proportion to the pipe diameter.

DESCRIPTION	DIAM IN	LONG RADIUS ELBOW			3D BEND		
		FLEX FACTOR	I/S(PIPE) IN	I/S(BEND) IN	FLEX FACTOR	I/S(PIPE) IN	I/S(BEND) IN
AP600	10.75	2.11	5.38	2.55	1.05	5.38	5.10
AP1000	14.00	2.22	7.00	3.16	1.11	7.00	6.32
RATIO AP1000/AP600	1.30		1.30	1.24		1.30	1.24
AP600	12.75	2.15	6.38	2.96	1.08	6.38	5.93
AP1000	18.00	2.26	9.00	3.99	1.13	9.00	7.98
RATIO AP1000/AP600	1.41		1.41	1.35		1.41	1.35

For seismic and deadweight loads, the moment in the pipe is proportional to weight of the pipe plus its contents. Since the ratio of the pipe diameter to the wall thickness is essentially the same for AP1000 and AP600, the seismic and deadweight moments are proportional to the pipe diameter. The seismic or deadweight stress in the pipe (stress equals moment/section modulus) is therefore proportional to 1.0/diameter. Based on these ratios, the following table shows that the seismic stress decreases approximately in proportion to the pipe diameter.

DESCRIPTION	DIAM IN	WEIGHT PIPE+WATER LBS/FT	S(PIPE) IN^3	WEIGHT/S LBS/FT/IN^3	1.0/DIAM IN^(-1)
AP600	10.75	141	74.3	1.89	0.093
AP1000	14.00	231	160	1.45	0.071
RATIO AP1000/AP600				0.77	0.77
AP600	12.75	195	123	1.59	0.078
AP1000	18.00	380	336	1.13	0.056
RATIO AP1000/AP600				0.71	0.71

The total (maximum LBB) pipe stress is the sum of the stresses due to internal pressure, thermal expansion, deadweight, and seismic loads, where deadweight, thermal, and seismic loads are combined by absolute summation. The corresponding normal LBB stress is the sum of the stresses due to internal pressure, thermal expansion, and deadweight loads, where the deadweight and thermal loads are combined by algebraic summation. When the diameter increases the thermal stress should increase and the deadweight and seismic stresses should decrease. The deadweight stress from the AP600 pipe stress analysis is not readily available in the Stress Reports which provide the total normal condition stress (pressure plus deadweight plus thermal). The deadweight plus thermal stress for AP600 is readily calculated by subtracting out the pressure stress. The deadweight plus thermal stress for AP1000 can be obtained by applying a factor to the AP600 stress. In order to obtain a high estimated or maximum value for the total stress, the deadweight plus thermal stress is assumed to be proportional to the pipe diameter. This is not a large affect since the deadweight stresses are usually smaller than the thermal stress. Therefore, in order to obtain a conservative estimate of the total pipe stress the following relations are used:

- Pressures stress is same as AP600.
- Deadweight and thermal stresses are proportional to the pipe diameter.
- Seismic stresses are proportional to 1.0/diameter.
- Seismic stresses are increased by the ratio of the AP1000 to AP600 peak acceleration per Section 2.1.

2.3 MATERIAL STRENGTH AFFECTS

When the estimated maximum pipe stress is above the BAC (in the region of the material flow stress) in the AP1000 Design Control Document, consideration is given to higher material strength properties that are more representative of the actual values obtained from test data for specific material heats. This raises the magnitude of the BAC in the region of the Curve that corresponds to the material flow stress. Westinghouse reviewed the certified material test reports of 316 type stainless steel material of auxiliary lines in operating plants for samples of 169 Heats. The average (mean value) of the flow stress for these material tests was 23.7% higher than the ASME Code minimum flow stress. The summary of the certified material test report review as well as the calculated mean values are provided in Appendix A. Westinghouse therefore adjusted the BAC wherever necessary to reflect a 20% to 23.7% increase in the flow stress. The flow

stress or the $3S_m$ values, whichever is the minimum, has been used. LBB analysis is typically performed using actual tested material properties of the piping system. Using approximately average material properties for the AP1000 assessment is appropriate given the high probability of reducing the piping stresses in the actual piping analysis. At worst, it is possible to specify easily obtainable new minimum material properties for the AP1000 pipe, should they be required by the results of the detailed piping analyses.

The use of certified material properties test reports has been accepted by the NRC on plant specific applications of LBB.

2.4 LEAK RATE AFFECTS

When the estimated maximum pipe stress is above the BAC in the AP1000 Design Control Document consideration is given to increasing the leak detection capability. This raises the magnitude of the BAC in the region of the Curve that is below the material flow stress. Lower leak rate detection capability has been reviewed and accepted by the NRC on operating plant specific applications of LBB. It is not expected that lowering the leak detection rate will be required for the AP1000. It is relatively easy to move the piping analysis stress points to the right in the BAC assessment by increasing the normal stress in the piping system based on piping system support modifications.

2.5 AP1000-SPECIFIC PIPE STRESS ANALYSIS

Westinghouse has performed a detailed pipe stress analysis of one piping system. The Direct Vessel Injection – A system was selected to be analyzed because it represents a limiting piping analysis considering the following criteria:

Complexity of piping system - The DVI-A piping system is complex, and was particularly challenging to qualify for the AP600. TheAP600 design and analysis of the DVI-A subsystem was performed over several iterations that included perturbations in the piping layout, support configuration, and piping analysis. Figure 9 shows isometric views of both the AP600 and AP1000 DVI-A piping system.

Low Margin to BAC for AP600 - The AP600 analysis results for the DVI-A line exhibited low margin to the AP600 BAC limits. In addition, the limit for one particular line segment actually exceeded the BAC. (For that segment, engineering judgement was used to determine that modification of the final support configuration would result in reducing the stress limits to below the BAC for that line segment). Therefore it is expected that the DVI-A would be one of the most difficult piping systems to qualify for LBB for the AP1000.

Minimum line size qualified for LBB - The DVI-A piping subsystem contains the smallest size line segment qualified for leak before break. Typically smaller lines are the most challenging to qualify for LBB. The DVI-A contains 6-inch piping, which is the smallest pipe size designated as LBB for the AP1000.

Potential for subcompartment pressurzation impact - The DVI-A traverses several subcompartments in the AP1000 containment. These subcompartments are not designed for the break of a high energy line of the size included in the DVI-A piping system. Therefore, if the DVI-A piping system were not qualified for LBB, additional subcompartment pressurization analyses would be required to demonstrate that the subcompartments are adequate.

Based on these considerations, Westinghouse decided to perform the detailed piping analysis of the DVI-A piping system to demonstrate that this limiting piping subsystem could be qualified for LBB. Results from the preliminary analyses for the DVI-A system are summarized in Table 3 and provided in Figures 10 through 15. The calculated stresses for the various line segments included in the DVI-A piping subsystem are below the BACs. The following table summarizes the results.

Table 3
Summary of DVI-A Preliminary Piping Stress Analysis Results

Pipe Segment	Maximum Calculated Stress (ksi)	Bounding Analysis Curve Limit (ksi)	Report Figure
8-inch, 316SS, 537F	23.9	41.6	Fig. 10
8-inch, 316SS, 120F	22.0	44.0	Fig. 11
8-inch, 304	13.8	14.4	Fig. 12
8-inch, Sch 40S	11.7	22.7	Fig. 13
6-inch, RNS	14.5	22.9	Fig. 14
8-inch, PXS	22.3	44.5	Fig. 15

These preliminary analysis results demonstrate the feasibility that the DVI-A piping subsystem can be qualified for LBB at the time of a COL application. The final analysis results for the DVI-A piping system will be made available to the NRC when they are completed.

3.0 ASSESSMENT RESULTS

This section provides the results of the AP1000 LBB assessment for each candidate line.

3.1 Primary Loop Hot Leg (31") – (Reference AP1000 DCD Figure 3B-2)

The Hot Leg pipe diameter is the same as AP600. The seismic multiplication factor is 1.74. This includes the affect of the higher elevation of the steam generator upper lateral support. The maximum stress is 29.5 ksi which is less than the BAC stress of 40.7 ksi. Figure 16 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

3.2 Primary Loop Cold Leg (22") – (Reference AP1000 DCD Figure 3B-3)

The Cold Leg pipe diameter is the same as AP600. The seismic multiplication factor is 1.74. This includes the affect of the higher elevation of the steam generator upper lateral support. The maximum stress is 42.6 ksi which is lower than the modified BAC stress of 49.9 ksi. Figure 17 shows the BAC and the estimated stresses for the AP1000 plant. Therefore, the feasibility of LBB for AP1000 is confirmed.

3.3 Pressurizer Surgeline (18") – (Reference AP1000 DCD Figure 3B-6)

The Surgeline pipe diameter is the same as AP600. The seismic multiplication factor is 1.36. This includes the affect of the higher elevation of the pressurizer center of gravity and the use of multiple input point seismic response spectra analysis. Applying the multiple input method in place of the envelope response spectra method reduces the SSE factor from 2.71 to 1.36. The damping value for the multiple input method is taken as 3% for the Surgeline. For the multiple input method an equivalent uniform acceleration is needed to apply to the AP600 SSE stresses. The equivalent uniform input is taken to be the peak spectral acceleration at the elevation of the center of gravity of the AP1000 Pressurizer Tank. This acceleration is higher than the AP600 peak spectral acceleration, which is at the top of the Pressurizer subcompartment walls. The maximum stress is 32.7 ksi which is less than the BAC stress of 40.3 ksi. Figure 18 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

3.4 ADS Stage 2 and 3 (14") – (Reference AP1000 DCD Figure 3B-10)

The Stage 2 and 3 pipe diameter is the same as AP600. The seismic multiplication factor is 2.71. This includes the affect of the higher elevation of the pressurizer upper lateral support. The maximum stress is 31.8 ksi which is less than the BAC stress of 40.3 ksi. Figure 19 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

3.5 ADS Stage 2 and 3 (8") – (Reference AP1000 DCD Figure 3B-16)

The Stage 2 and 3 pipe diameter is the same as AP600. The seismic multiplication factor is 2.71. This includes the affect of the higher elevation of the pressurizer upper lateral support. The maximum stress is approximately 48 ksi which is more than the BAC stress of 40 ksi. Using more realistic material strength the modified BAC stress limit can be increased to 48 ksi. Figure 20 shows the BAC and the estimated stresses for the AP1000 plant. Therefore, the feasibility of LBB for AP1000 is confirmed.

3.6 Pressurizer Safety (6") – (Reference AP1000 DCD Figure 3B-19)

The Pressurizer Safety pipe diameter is the same as AP600. The seismic multiplication factor is 2.71. This includes the affect of the higher elevation of the pressurizer upper lateral support. The maximum stress is 61.9 ksi which is higher than the BAC stress of 40.4 ksi. Figure 21 shows the BAC and the estimated stresses for the AP1000 plant. This stress is calculated based on the conservative methods previously described in Section 2. Utilizing detailed time-history seismic analysis methods as opposed to response spectra methods previously utilized for AP600, it is anticipated that the analytical results will be significantly lower than those obtained by the conservative ratios developed. In the event that the results from the detailed time-history seismic results still exceed the BAC limits, the affects of postulated high energy line pipe breaks in the two 6" Safety lines would need to be evaluated. These pipe breaks are above the top of the Pressurizer subcompartment walls, and do not effect the design for subcompartment pressurization. Therefore the breaks would not have any adverse impact on the structural design of the Containment Internal Structure. Pipe whip restraints can be installed on the ADS pressurizer platforms at the locations shown in Figure 22 to ensure that the adjacent components that are needed to mitigate the pipe break (i.e. ADS Stage 1, 2, and 3 valves and piping)are not compromised.

3.7 ADS Stage 4 East (18") – (Reference AP1000 DCD Figure 3B-7)

The ADS Stage 4 pipe diameter is larger than the AP600 (12"). The seismic multiplication factor is 1.42. This includes the affect of the higher elevation of the steam generator upper lateral support in the East Subcompartment. The maximum stress is 26.3 ksi before adjustment for pipe diameter and 30.9 ksi after adjustment. The adjusted stress is less than the BAC stress of 40.7 ksi. Figure 23 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

3.8 ADS Stage 4 West (18") – (Reference AP1000 DCD Figure 3B-7)

The ADS Stage 4 pipe diameter is larger than the AP600 (12"). The seismic multiplication factor is 1.74. This includes the affect of the higher elevation of the steam generator upper lateral support in the West subcompartment. The maximum stress is 20.4 ksi before adjustment for pipe diameter and 23.2 ksi after adjustment. The adjusted stress is less than the BAC stress of 40.7 ksi. Figure 23 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

3.9 ADS Stage 4 East (14"- 610F) - (Reference AP1000 DCD Figure 3B-8)

The ADS Stage 4 pipe diameter is larger than the AP600 (10"). The seismic multiplication factor is 1.42. This includes the affect of the higher elevation of the steam generator upper lateral support. The maximum stress is 31.4 ksi before adjustment for pipe diameter and 34.8 ksi after adjustment. The adjusted stress is less than the BAC stress of 40.7 ksi. Figure 24 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

3.10 ADS Stage 4 West (14"- 610F) – (Reference AP1000 DCD Figure 3B-8)

The ADS Stage 4 pipe diameter is larger than the AP600 (10"). The seismic multiplication factor is 1.74. This includes the affect of the higher elevation of the steam generator upper lateral support. The maximum stress is 32.7 ksi before adjustment for pipe diameter and 27.0 ksi after adjustment. The adjusted stress is less than the corresponding BAC stress of 31.6 ksi. Figure 24 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

3.11 ADS Stage 4 East (14"- 120F) – (Reference AP1000 DCD Figure 3B-9)

The ADS Stage 4 pipe diameter is larger than the AP600 (10"). The seismic multiplication factor is 1.42. This includes the affect of the higher elevation of the steam generator upper lateral support. The maximum stress is 30.4 ksi before adjustment for pipe diameter and 32.9 ksi after adjustment. The adjusted stress is less than the BAC stress of 51.9 ksi. Figure 25 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

3.12 ADS Stage 4 West (14"- 120F) – (Reference AP1000 DCD Figure 3B-9)

The ADS Stage 4 pipe diameter is larger than the AP600 (10"). The seismic multiplication factor is 1.74. This includes the affect of the higher elevation of the steam generator upper lateral support. The maximum stress is 26.7 ksi before adjustment for pipe diameter and 24.4 ksi after adjustment. The adjusted stress is less than the BAC stress of 51.9 ksi. Figure 25 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

3.13 Normal RHR Suction (20") – (Reference AP1000 DCD Figure 3B-5)

The Normal RHR Suction pipe diameter is the same as AP600. The seismic multiplication factor is 1.42. This includes the affect of the higher elevation of the steam generator upper lateral support in the East subcompartment. The maximum stress is 17.9 ksi which is less than the BAC stress of 40.7 ksi. Figure 26 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

3.14 Normal RHR Suction (12") – (Reference AP1000 DCD Figure 3B-20)

The Normal RHR Suction pipe diameter is the same as AP600. The seismic multiplication factor is 1.42. This includes the affect of the higher elevation of the steam generator upper lateral

support in the East subcompartment. The maximum stress is 30.0 ksi which is less than the BAC stress of 40.7 ksi. Figure 27 shows the BAC and the estimated stresses for the AP1000 plant. The feasibility of LBB for AP1000 is confirmed.

3.15 Normal RHR Suction (10") – (Reference AP1000 DCD Figure 3B-21)

The Normal RHR Suction pipe diameter is the same as AP600. The seismic multiplication factor is 1.42. This includes the affect of the higher elevation of the steam generator upper lateral support in the East subcompartment. The maximum stress is 38.9 ksi which is less than the BAC stress of 40.7 ksi. Figure 28 shows the BAC and the estimated stresses for the AP1000 plant. The feasibility of LBB for AP1000 is confirmed.

3.16 Passive RHR Return (14") – (Reference AP1000 DCD Figure 3B-11)

The Passive RHR Return pipe diameter is larger than the AP600 (10"). The seismic multiplication factor is 1.74. This includes the affect of the higher elevation of the steam generator upper lateral support in the West subcompartment. The maximum stress is 59.1 ksi before adjustment for pipe diameter and 51.4 ksi after adjustment. The adjusted stress is higher than the BAC stress of 41.6 ksi. Using more realistic material strength the modified BAC stress limit is 51.4 ksi. Figure 29 shows the BAC and the estimated stresses for the AP1000 plant. Therefore, the feasibility of LBB for AP1000 is confirmed.

3.17 Direct Vessel Injection (DVI) – B (8", (316SS, 537F)) – (Reference AP1000 DCD Figure 3B-14)

The DVI-B (8", 316SS, 537F) pipe diameter is the same as AP600. The seismic multiplication factor is 1.28. This includes the elevation of the reactor vessel support. The maximum stress is 30.3 ksi which is less than the BAC stress of 41.6 ksi. Figure 30 shows the BAC and the estimated stresses for the AP1000 plant. The feasibility of LBB for AP1000 is confirmed.

3.18 Direct Vessel Injection (DVI) – B (8", (316SS, 120F)) – (Reference AP1000 DCD Figure 3B-15)

The DVI-B (8", 316SS, 120F) pipe diameter is the same as AP600. The seismic multiplication factor is 1.28. This includes the elevation of the reactor vessel support. The maximum stress is 23.7 ksi which is less than the corresponding BAC stress of 48.6 ksi. Figure 31 shows the BAC and the estimated stresses for the AP1000 plant. The feasibility of LBB for AP1000 is confirmed.

3.19 Direct Vessel Injection (DVI) – B (8", (304)) – (Reference AP1000 DCD Figure 3B-17)

The DVI-B (8", 304) pipe diameter is the same as AP600. The seismic multiplication factor is 1.28. This includes the elevation of the reactor vessel support. The maximum stress is 8.7 ksi which is less than the corresponding BAC stress of 10.5 ksi. Figure 32 shows the BAC and the estimated stresses for the AP1000 plant. The feasibility of LBB for AP1000 is confirmed.

3.20 Direct Vessel Injection (DVI) – B (8", (Sch 40S)) – (Reference AP1000 DCD Figure 3B-13)

The DVI-B (8", Sch 40S) pipe diameter is the same as AP600. The seismic multiplication factor is 1.28. This includes the elevation of the reactor vessel support. The maximum stress is 16.2 ksi which is less than the corresponding BAC stress of 21.3 ksi. Figure 33 shows the BAC and the estimated stresses for the AP1000 plant. The feasibility of LBB for AP1000 is confirmed.

3.21 Direct Vessel Injection (DVI) – B (6", RNS) – (Reference Figure 3B-18)

The DVI-B (6", RNS) pipe diameter is the same as AP600. The seismic multiplication factor is 1.28. This includes the elevation of the reactor vessel support. The maximum stress is 17.2 ksi which is less than the corresponding BAC stress of 27.0 ksi. Figure 34 shows the BAC and the estimated stresses for the AP1000 plant. The feasibility of LBB for AP1000 is confirmed.

3.22 Direct Vessel Injection (DVI) – B (8", PXS) – (Reference AP1000 DCD Figure 3B-15)

The DVI-B (8", PXS) pipe diameter is larger than the AP600. The seismic multiplication factor is 1.28. This includes the elevation of the reactor vessel support. The maximum stress is 26.6 ksi before adjustment for pipe diameter and 23.8 ksi after adjustment. The adjusted stress is less than the corresponding BAC stress of 35.2 ksi. Figure 35 shows the BAC and the estimated stresses for the AP1000 plant. The feasibility of LBB for AP1000 is confirmed.

3.23 Core Makeup Tank Supply – West (8") – (Reference AP1000 DCD Figure 3B-14)

The Core Makeup Tank Supply–West pipe diameter is the same as AP600. The seismic multiplication factor is 1.74. This includes the affect of the higher elevation of the steam generator upper lateral support in the West subcompartment. The maximum stress is 43.1 ksi which is higher than the BAC stress of 41.6 Using more realistic material strength the modified BAC stress limit is 50.0 ksi. Figure 36 shows the BAC and the estimated stresses for the AP1000 plant. The feasibility of LBB for AP1000 is confirmed.

3.24 Core Makeup Tank Supply – East (8") – (Reference AP1000 DCD Figure 3B-14)

The Core Makeup Tank Supply–East pipe diameter is the same as AP600. The seismic multiplication factor is 1.42. This includes the affect of the higher elevation of the steam generator upper lateral support in the East subcompartment. The maximum stress is 41.0 ksi which is higher than the corresponding BAC stress limit. Using more realistic material strength and the lower leak detection capability of 0.25 gpm the modified BAC stress limit of 42.8 ksi. Figure 36 shows the BAC and the estimated stresses for the AP1000 plant. The feasibility of LBB for AP1000 is confirmed.

3.25 Main Steam – A – West (38") – (Reference AP1000 DCD Figure 3B-4)

The Main Steam – A-West pipe diameter is larger than the AP600. The seismic multiplication factor is 1.74. This includes the affect of the higher elevation of the steam generator upper lateral support in the West subcompartment. The maximum stress is 27.7 ksi before adjustment for pipe diameter and 24.5 ksi after adjustment. The adjusted stress is higher than the corresponding BAC stress limit of 21.0 ksi. Using a lower leak detection capability of 0.25 gpm, the modified BAC stress limit is 25.9 ksi. Figure 37 shows the BAC and the estimated stresses for the AP1000 plant. The feasibility of LBB for AP1000 is confirmed. An alternative approach is to modify the pipe support configuration to shift the frequency response of the piping system away from the peak response spectra accelerations, thus producing a lower maximum stress point below the original BAC stress limit. Additionally, if required, detailed time-history seismic analysis methods could be used as opposed to envelope response spectra methods to obtain further reduction in the corresponding seismic stresses.

3.26 Main Steam – B – East (38") – (Reference AP1000 DCD Figure 3B-4)

The Main Steam – B-East pipe is similar to the West pipe. Stress estimates were not specifically calculated for this line. By similarity, the feasibility of LBB for AP1000 is confirmed.

4.0 4th Stage Automatic Depressurization System Evaluation

The Automatic Depressurization System (ADS) consists of four actuation stages and provides for Emergency Core Cooling following postulated accident conditions. These four stages are independent of each other and open sequentially, stage 1 through stage 4. The 4th stage ADS connects directly to the Reactor Coolant Hot Leg and vents into the applicable Steam Generator Compartment. This system can not operate until reactor coolant pressure has been significantly reduced.

Due to the critical nature of this system, an additional assessment of the seismic loadings is performed to further demonstrate the feasibility of Leak-Before-Break for these lines. The applicable seismic response spectra are reviewed for the 4th stage ADS, East and West, and the maximum increase in response spectra acceleration identified based on individual frequency. This review results in the following seismic increase factors as shown in Figures 38 and 39:

Location	Frequency	Increase Factor
Elevation 135' - X direction	8 Hz	2.1
Elevation 153' - Z direction	10 Hz	2.0

This approach adds an additional level of conservatism to the methodology described in Section 2.1

Results of the 4th Stage ADS seismic assessment are summarized in the following sections.

4.1 ADS Stage 4 East (18") – (Reference AP1000 DCD Figure 3B-7)

The ADS Stage 4 pipe diameter is larger than the AP600 (12"). Per Figure 38, the seismic increase factor is 2.1 based on the seismic response spectra at approximately 8 Hz. The maximum stress is 33.0 ksi accounting for both the seismic increase factor and the increase in pipe diameter. The adjusted stress is less than the BAC stress of 40.7 ksi. Figure 40 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

4.2 ADS Stage 4 West (18") – (Reference AP1000 DCD Figure 3B-7)

The ADS Stage 4 pipe diameter is larger than the AP600 (12"). Per Figure 39, the seismic increase factor is 2.0 based on the seismic response spectra at approximately 10 Hz. The maximum stress is 23.7 ksi accounting for both the seismic increase factor and the increase in pipe diameter. The adjusted stress is less than the BAC stress of 40.7 ksi. Figure 40 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

4.3 ADS Stage 4 East (14"- 610F) - (Reference AP1000 DCD Figure 3B-8)

The ADS Stage 4 pipe diameter is larger than the AP600 (10"). Per Figure 38, the seismic increase factor is 2.1 based on the seismic response spectra at approximately 8 Hz. The maximum stress is 38.0 ksi accounting for both the seismic increase factor and the increase in pipe diameter. The adjusted stress is less than the BAC stress of 40.7 ksi. Figure 41 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

4.4 ADS Stage 4 West (14"- 610F) – (Reference AP1000 DCD Figure 3B-8)

The ADS Stage 4 pipe diameter is larger than the AP600 (10"). Per Figure 39, the seismic increase factor is 2.0 based on the seismic response spectra at approximately 10 Hz. The maximum stress is 30.0 ksi accounting for both the seismic increase factor and the increase in pipe diameter. The adjusted stress is less than the BAC stress of 31.6 ksi. Figure 41 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

4.5 ADS Stage 4 East (14"- 120F) – (Reference AP1000 DCD Figure 3B-9)

The ADS Stage 4 pipe diameter is larger than the AP600 (10"). Per Figure 38, the seismic increase factor is 2.1 based on the seismic response spectra at approximately 8 Hz. The maximum stress is 36.5 ksi accounting for both the seismic increase factor and the increase in pipe diameter. The adjusted stress is less than the BAC stress of 51.9 ksi. Figure 42 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

4.6 ADS Stage 4 West (14"- 120F) – (Reference AP1000 DCD Figure 3B-9)

The ADS Stage 4 pipe diameter is larger than the AP600 (10"). Per Figure 39, the seismic increase factor is 2.0 based on the seismic response spectra at approximately 10 Hz. The maximum stress is 26.4 ksi accounting for both the seismic increase factor and the increase in pipe diameter. The adjusted stress is less than the BAC stress of 51.9 ksi. Figure 41 shows the BAC and the estimated stresses for the AP1000 plant. Feasibility of LBB for AP1000 is confirmed.

5.0 SUMMARY

This report summarizes an assessment of applying Leak-Before-Break methodology to the candidate AP1000 plant pipe lines listed in Table 1. Feasibility is demonstrated for the LBB candidate piping systems with one possible exception of the Pressurizer Safety Valve inlet piping (6"). For these two lines, the high energy pipe breaks can be mitigated by the installation of protection devices (whip restraints) as shown at the locations in Figure 22 if required.

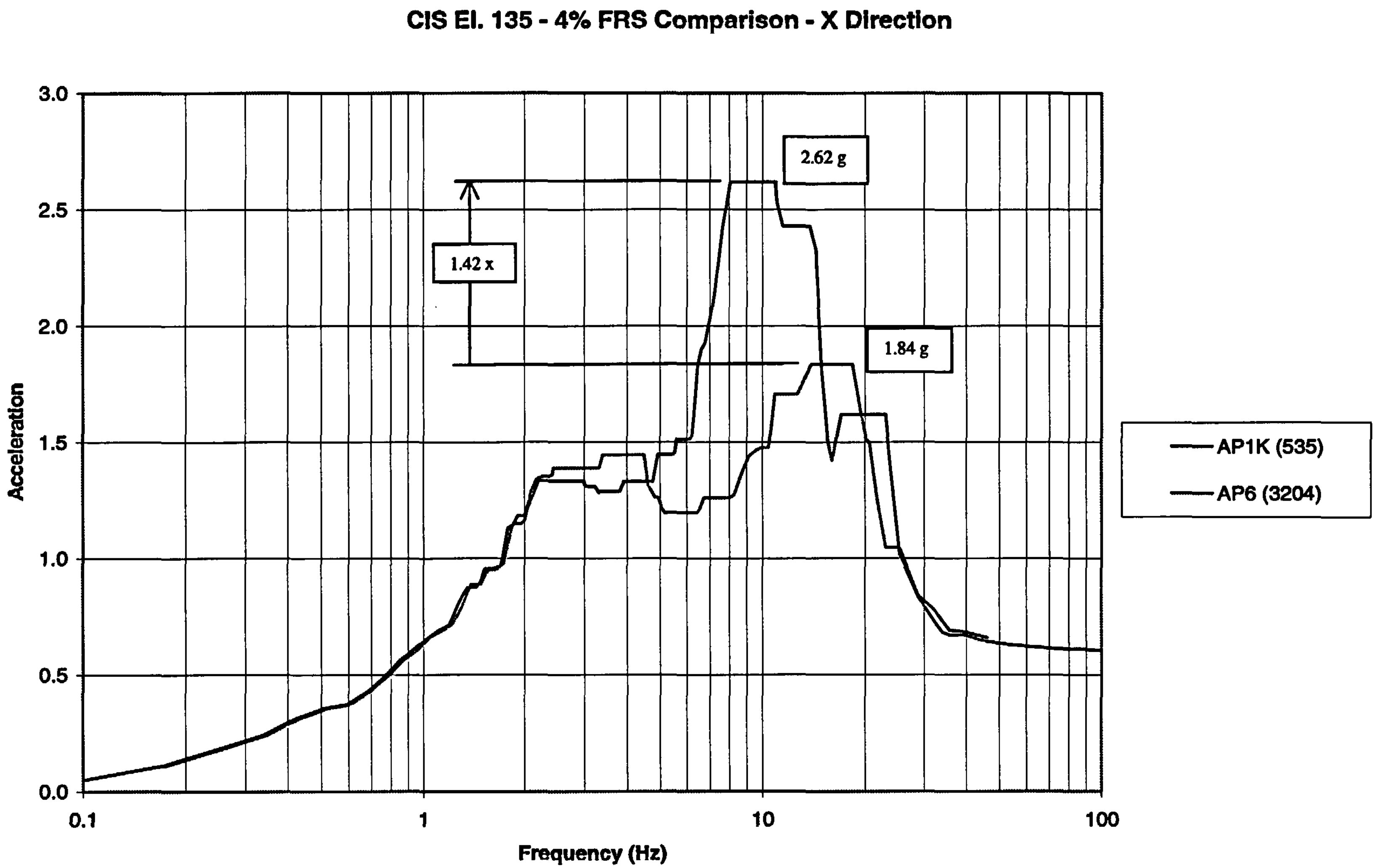


Figure 1 - In-Structure Seismic Response Spectra, Steam Generator Support Elev. 135', (North-South)

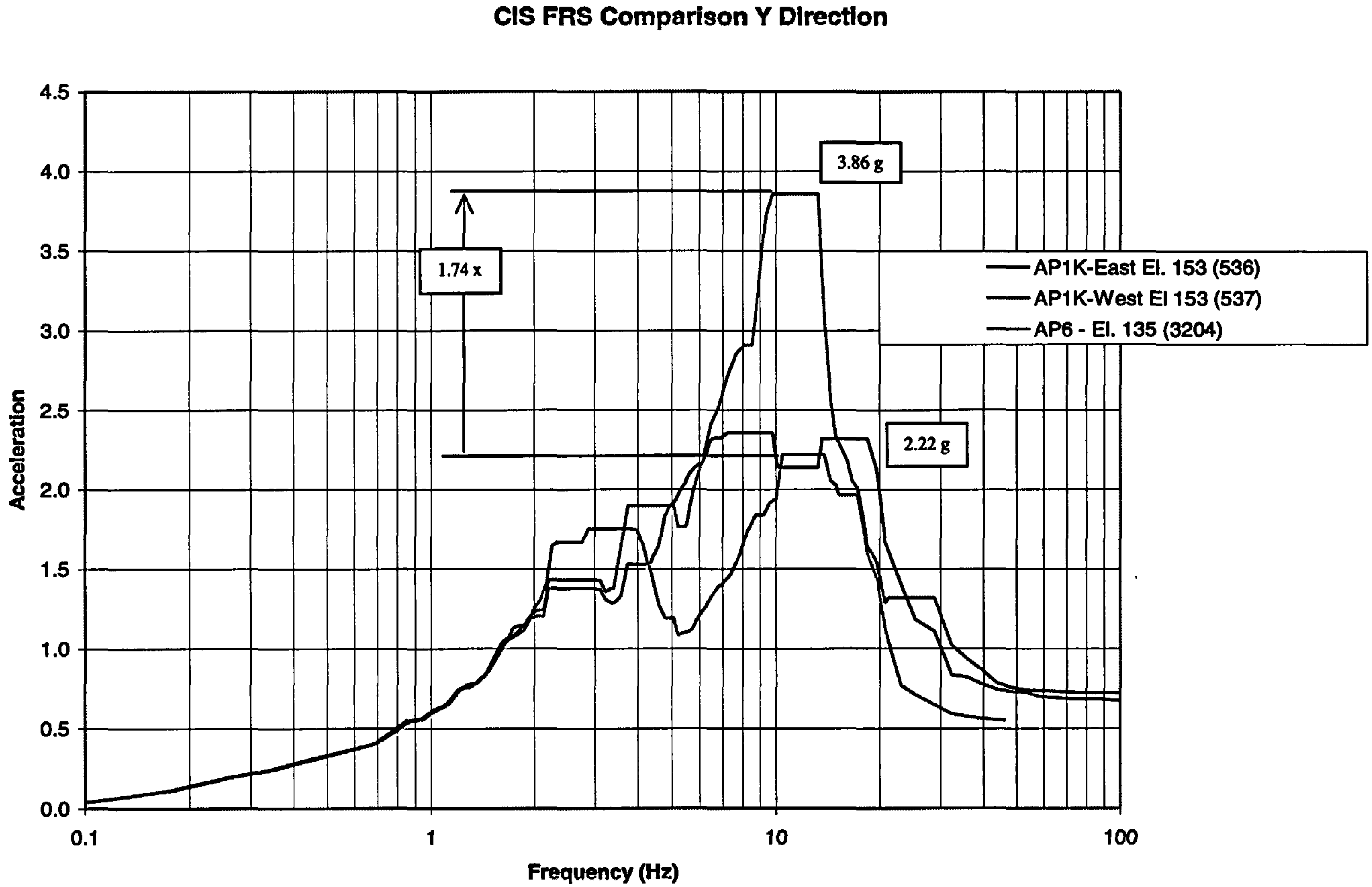


Figure 2 - In-Structure Seismic Response Spectra, Steam Generator Support Elev. 153', (East-West)

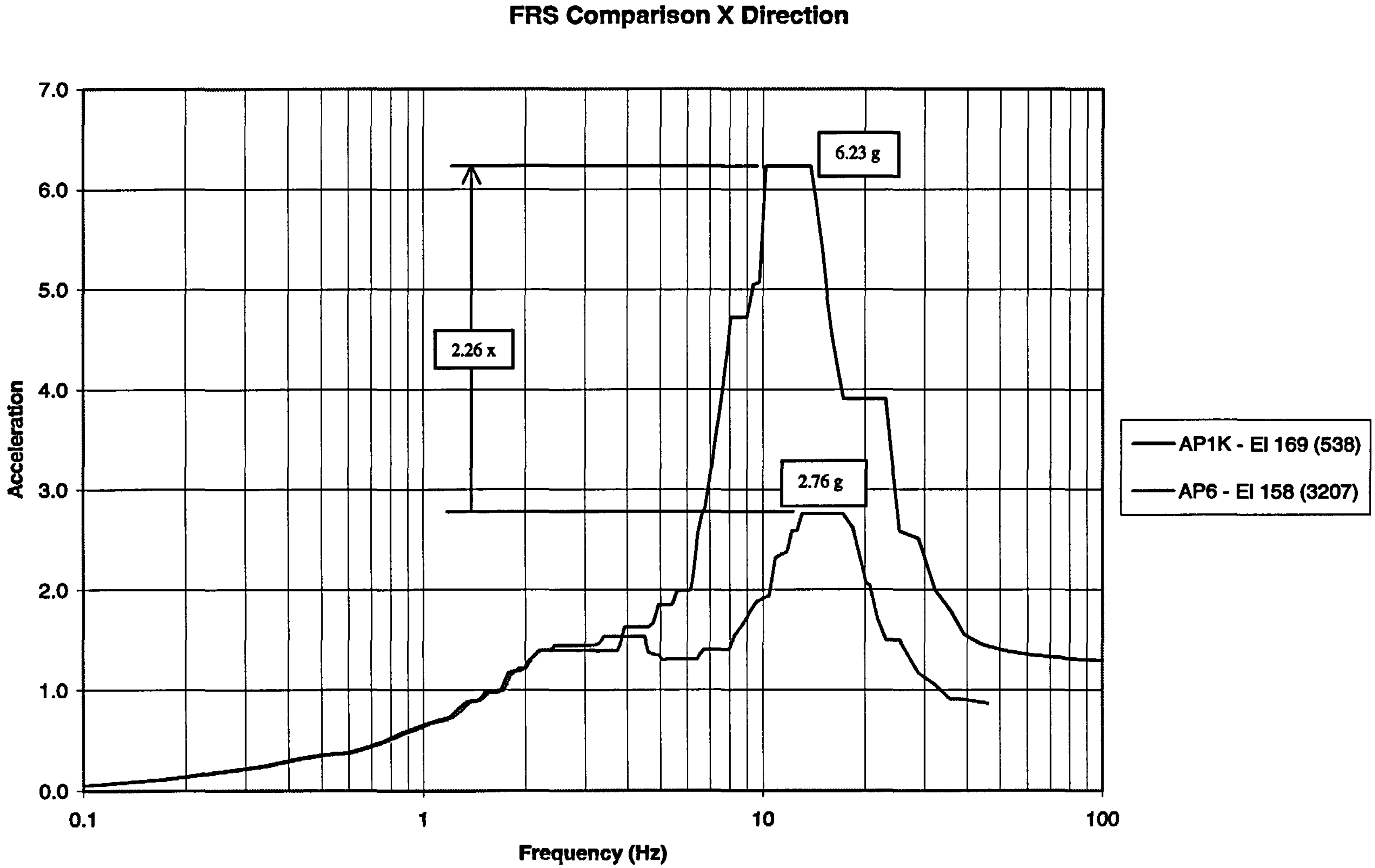


Figure 3 - In-Structure Seismic Response Spectra, Pressurizer Support, (North-South)

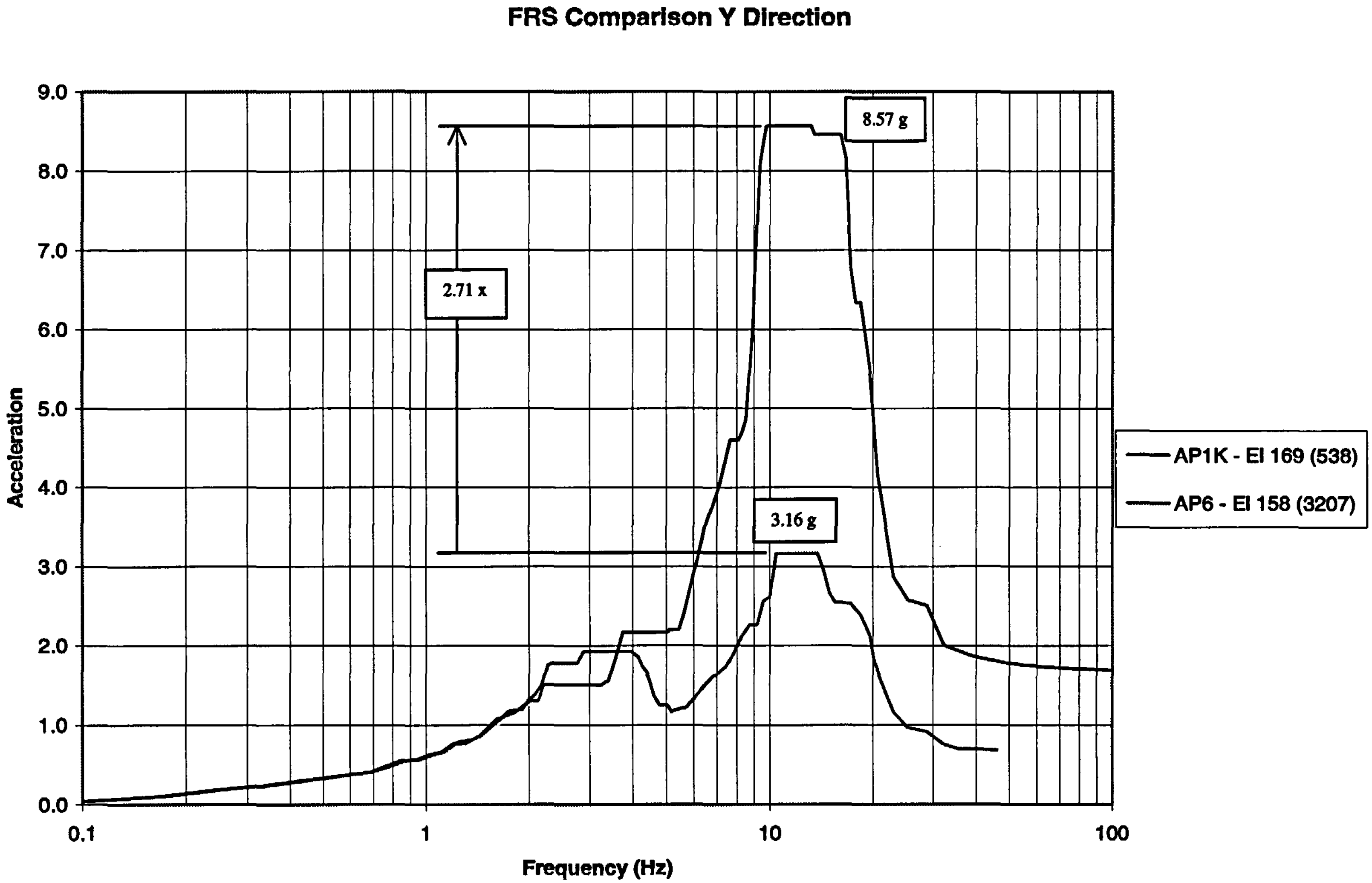


Figure 4 - In-Structure Seismic Response Spectra, Pressurizer Support, (East-West)

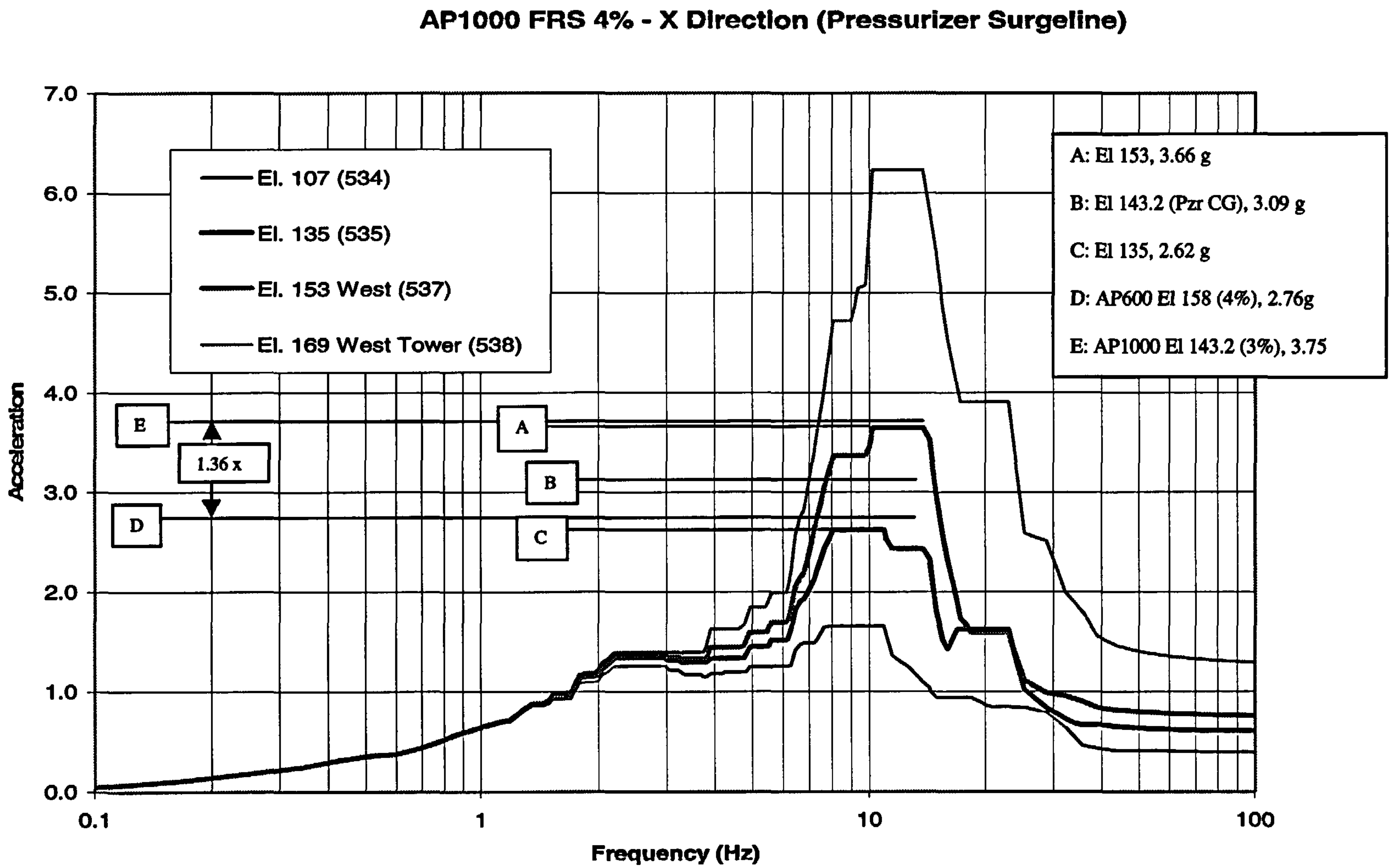


Figure 5 - In-Structure Seismic Response Spectra, Pressurizer Center of Gravity, (North –South)

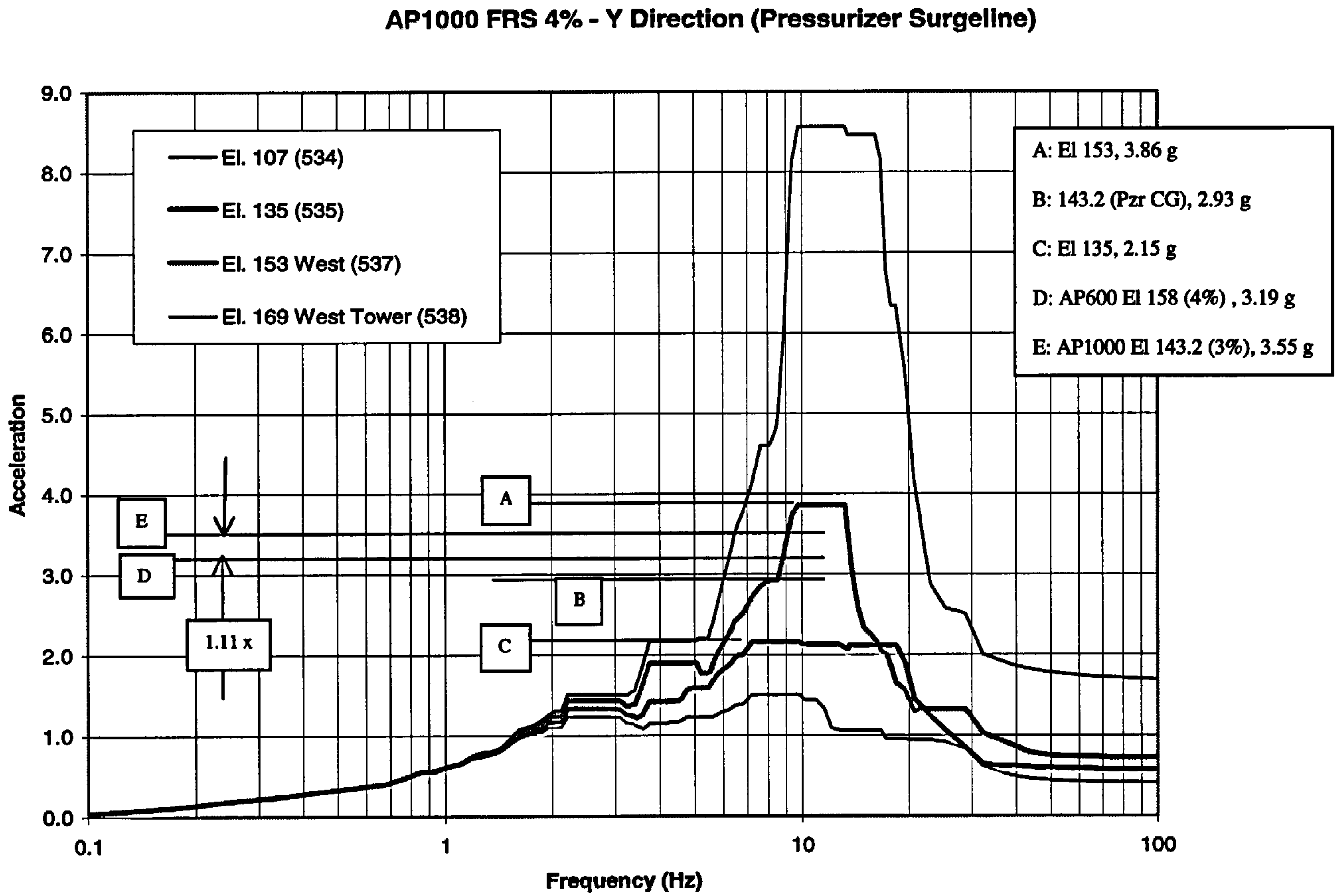


Figure 6 - In-Structure Seismic Response Spectra, Pressurizer Center of Gravity, (East-West)

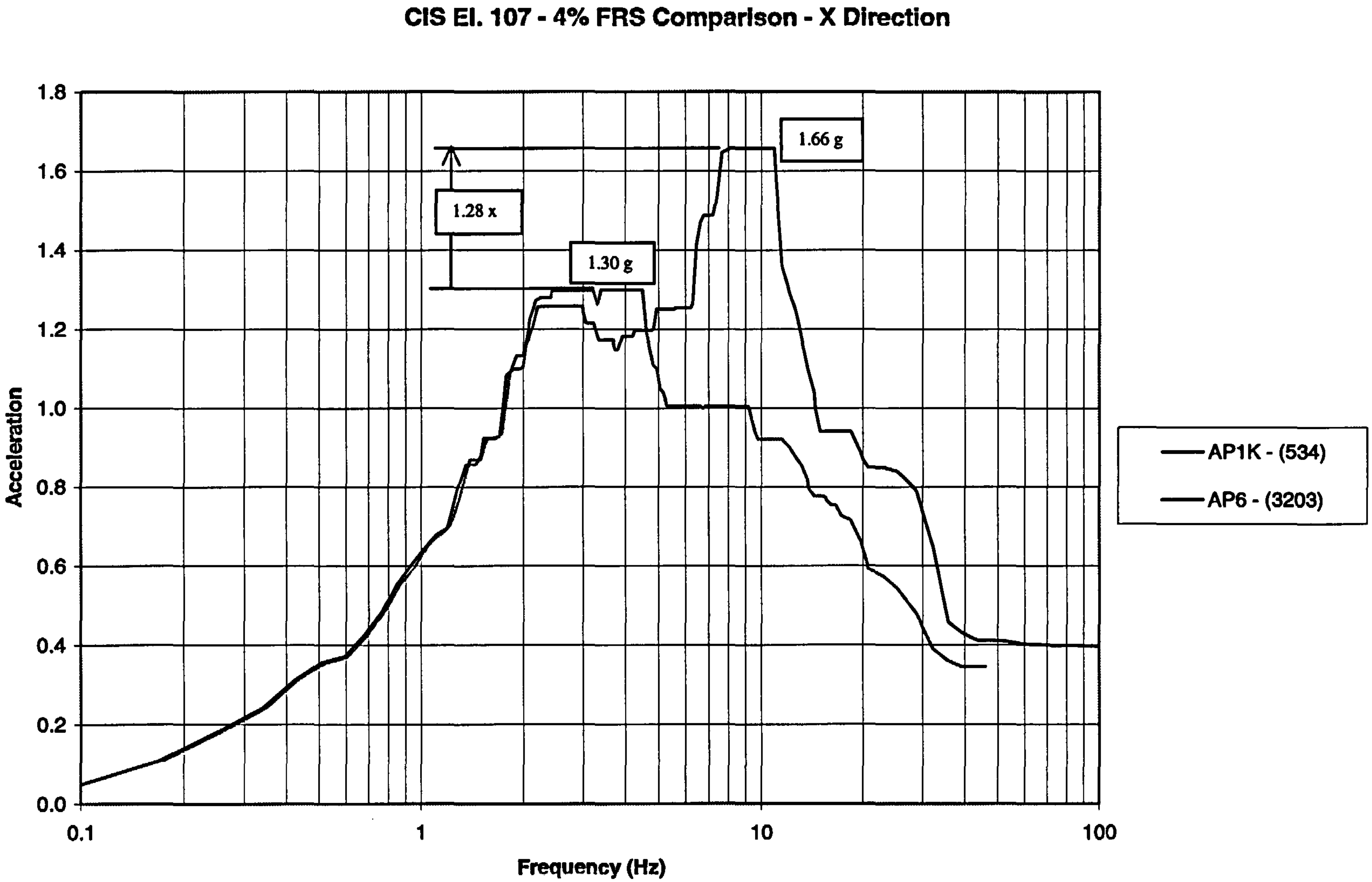


Figure 7 - In-Structure Seismic Response Spectra, Reactor Vessel Support, (North-South)

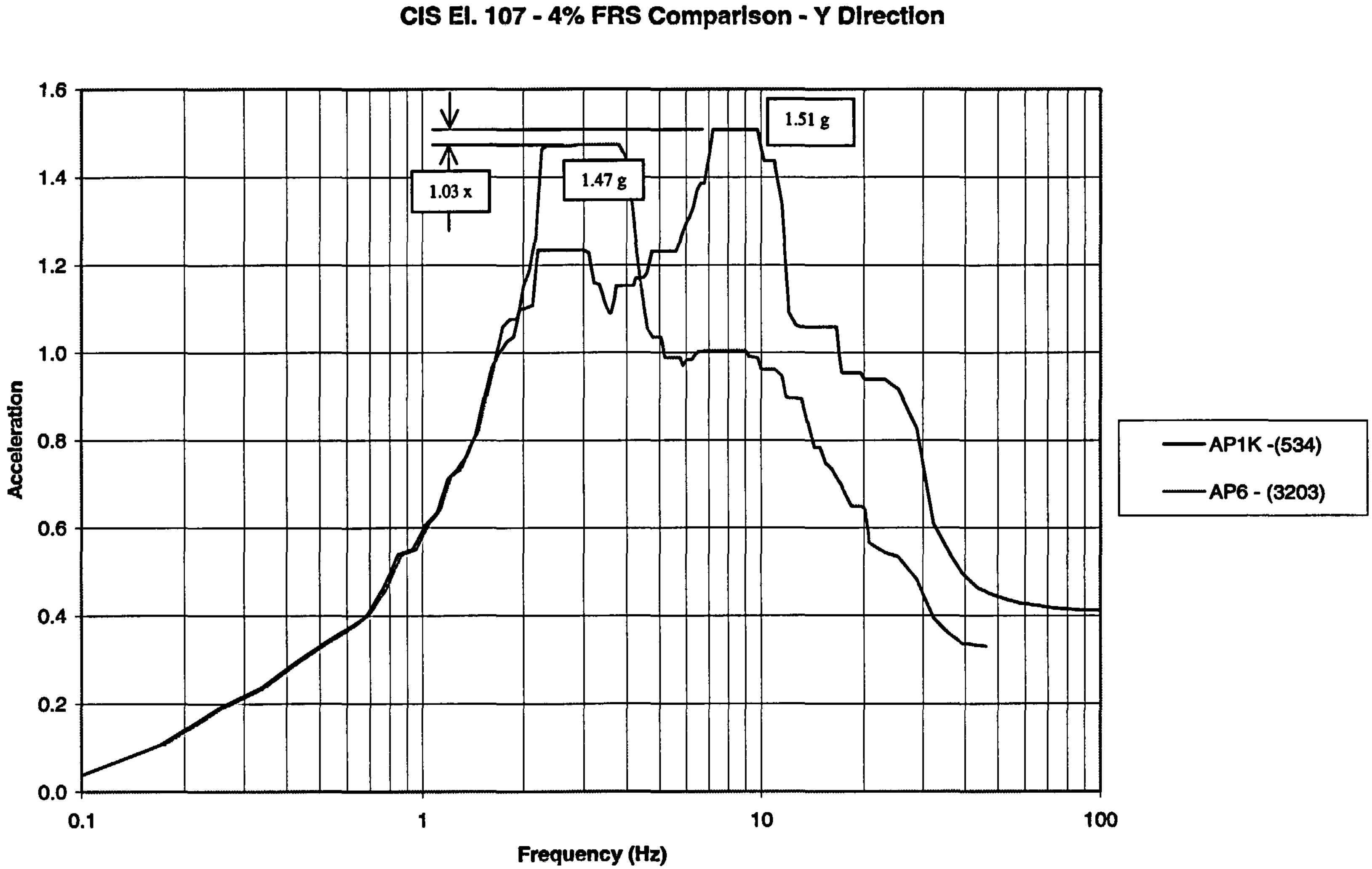
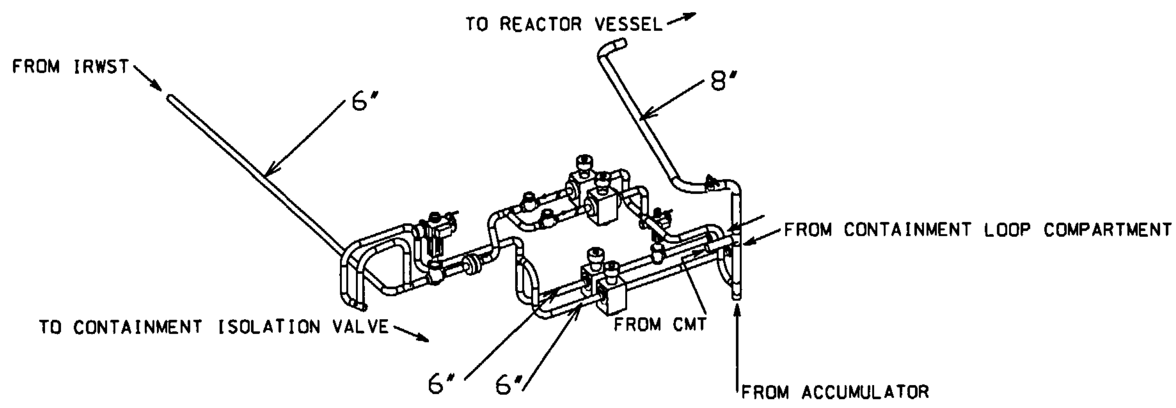
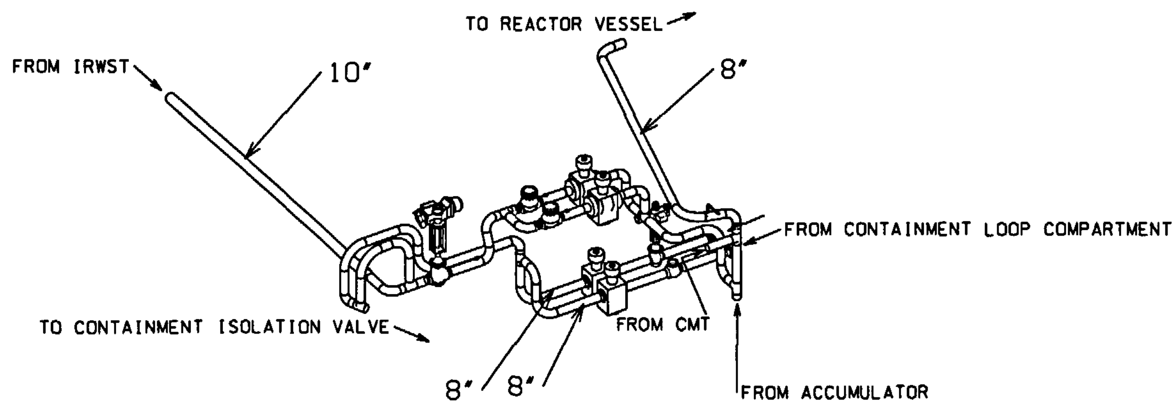


Figure 8 - In-Structure Seismic Response Spectra, Reactor Vessel Support, (East-West)



DVIA-AP600



DVIA-1000

Figure 9 – Isometric View: Comparison of AP600 and AP1000 DVI-A Piping System

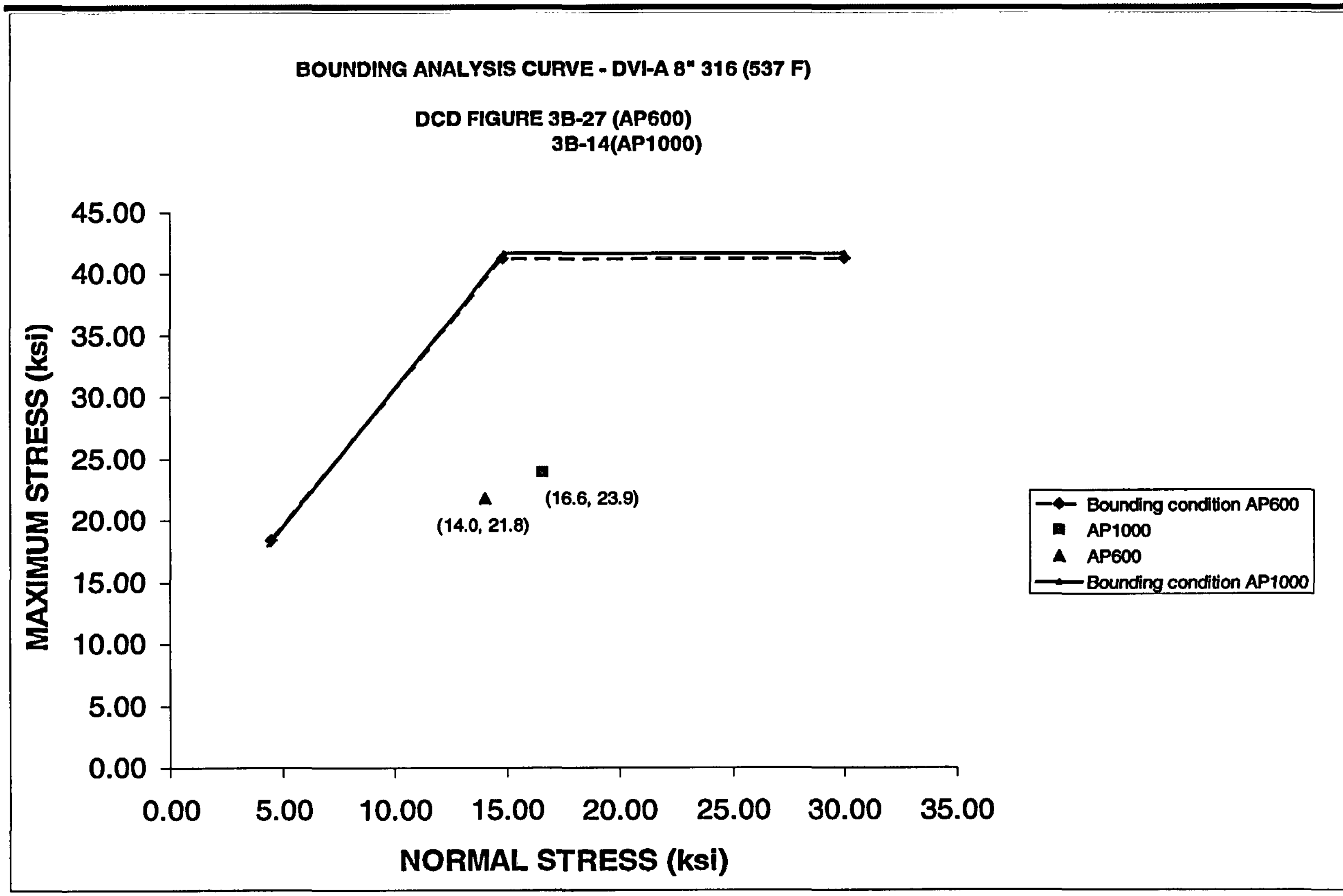


Figure 10 - Bounding Analysis Curve – DVI-A – 8" (316 SS, 537 °F)

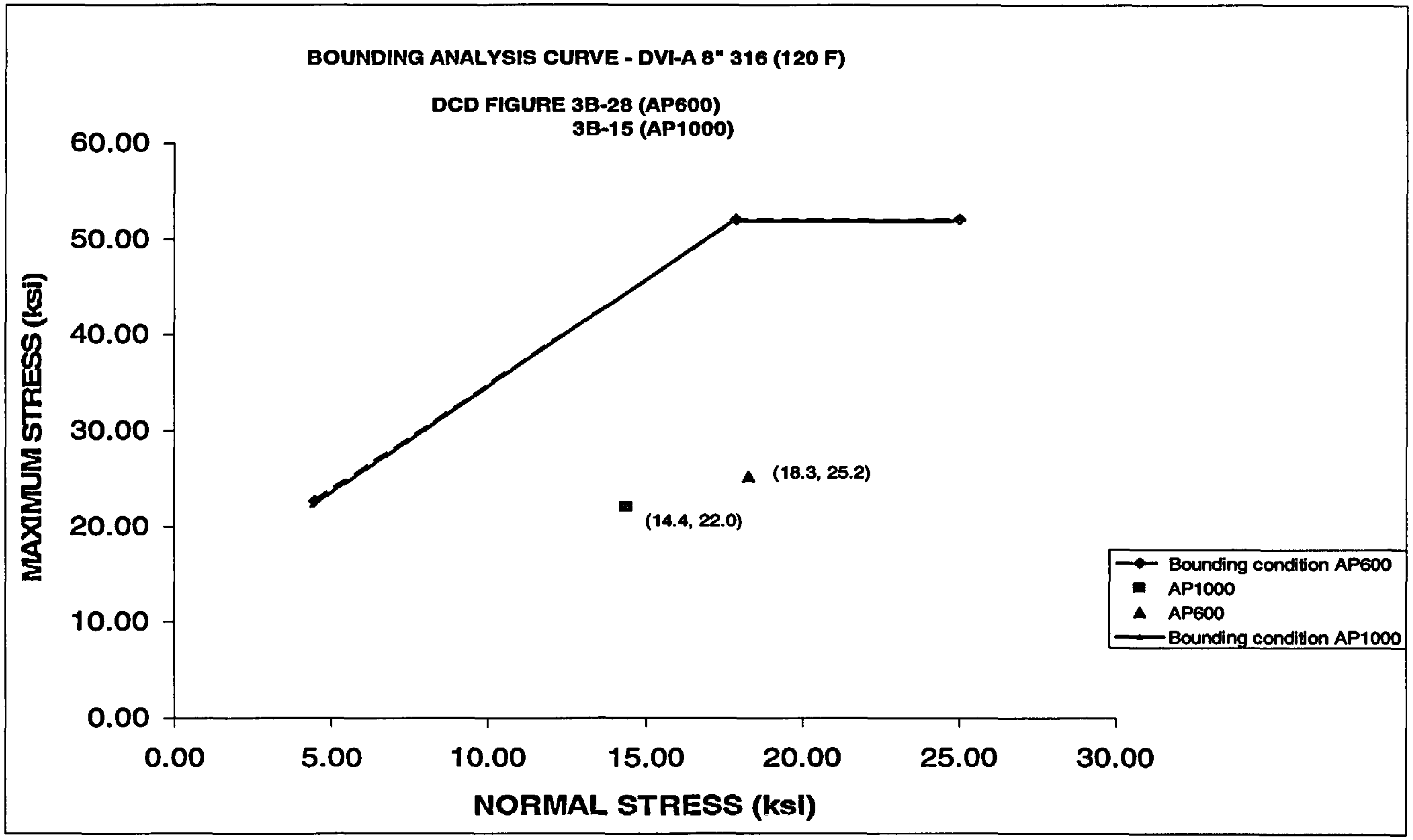


Figure 11 - Bounding Analysis Curve – DVI-A – 8" (316 SS, 120 °F)

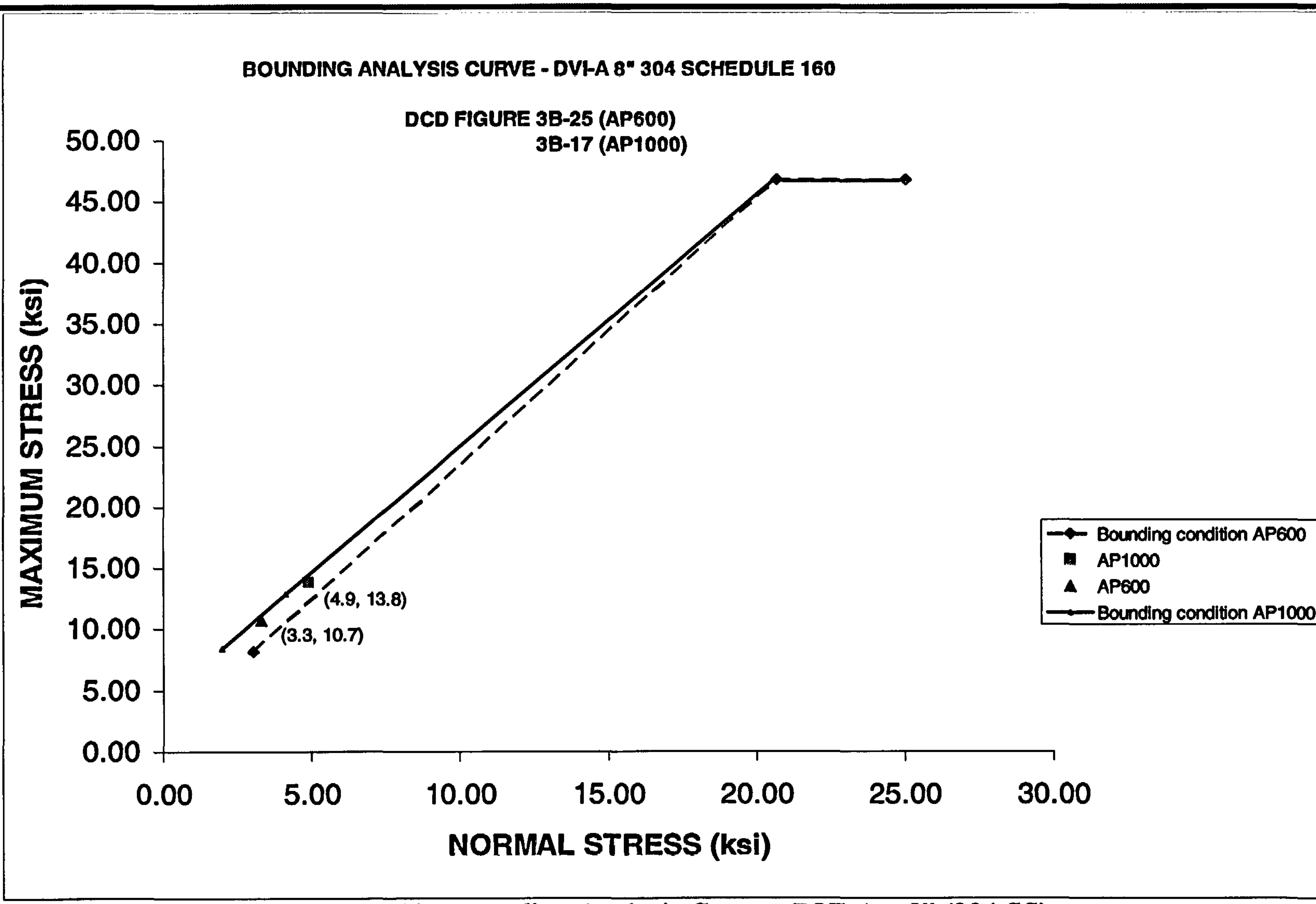


Figure 12 - Bounding Analysis Curve – DVI-A – 8" (304 SS)

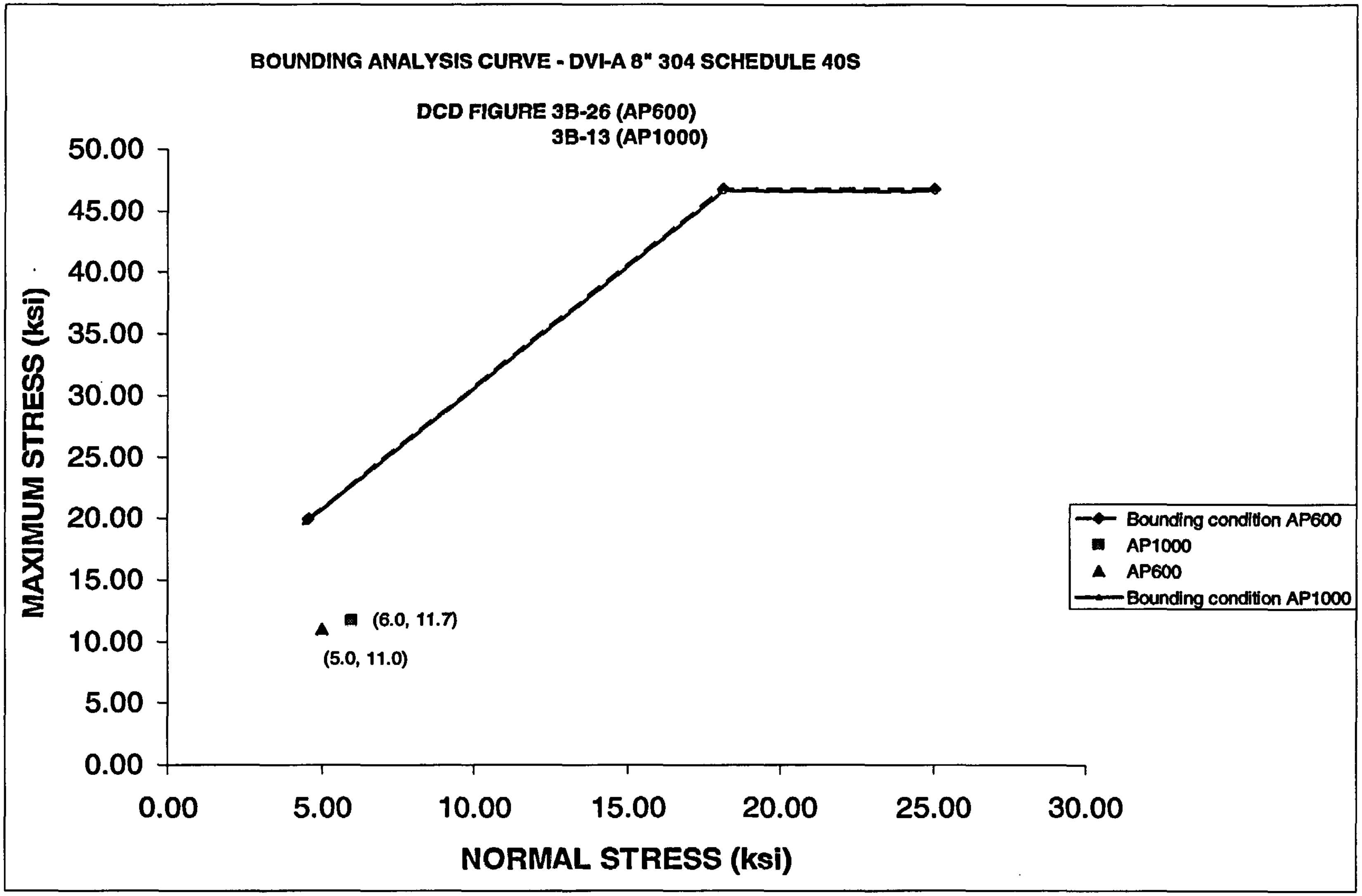


Figure 13 - Bounding Analysis Curve – DVI-A – 8" (Sch 40S)

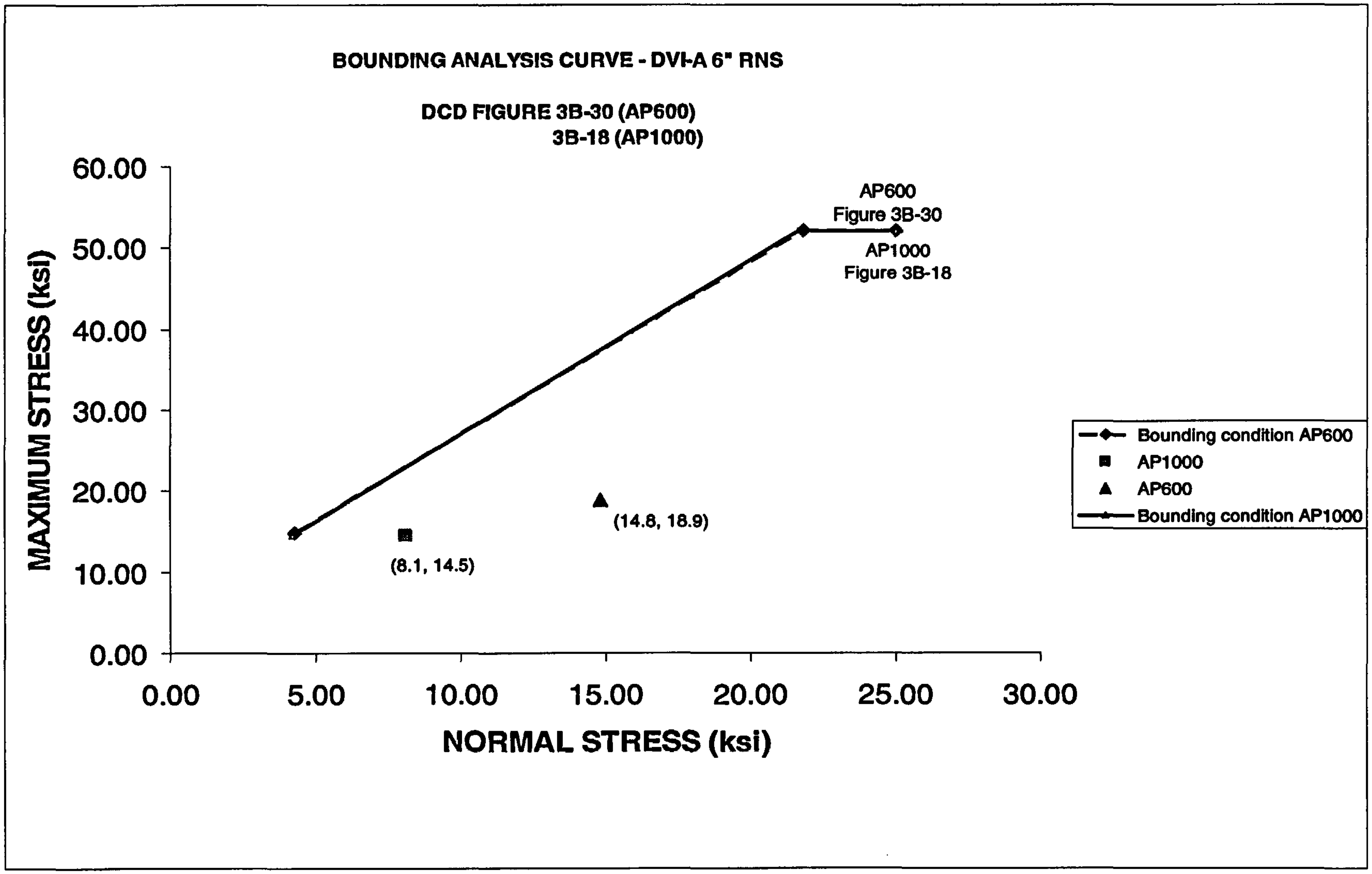


Figure 14 - Bounding Analysis Curve – DVI-A – 6" RNS

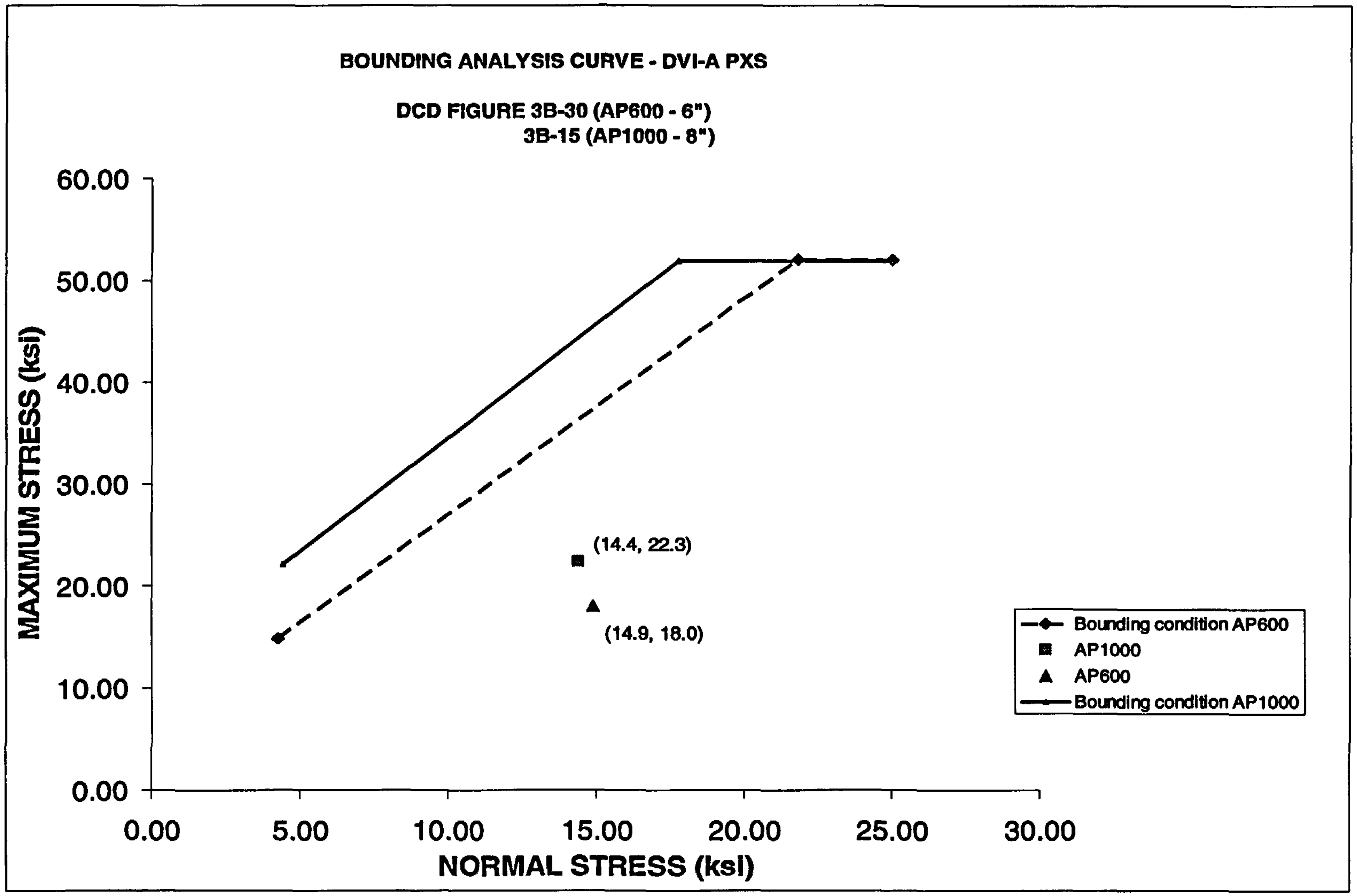


Figure 15 - Bounding Analysis Curve – DVI-A – 8" PXS

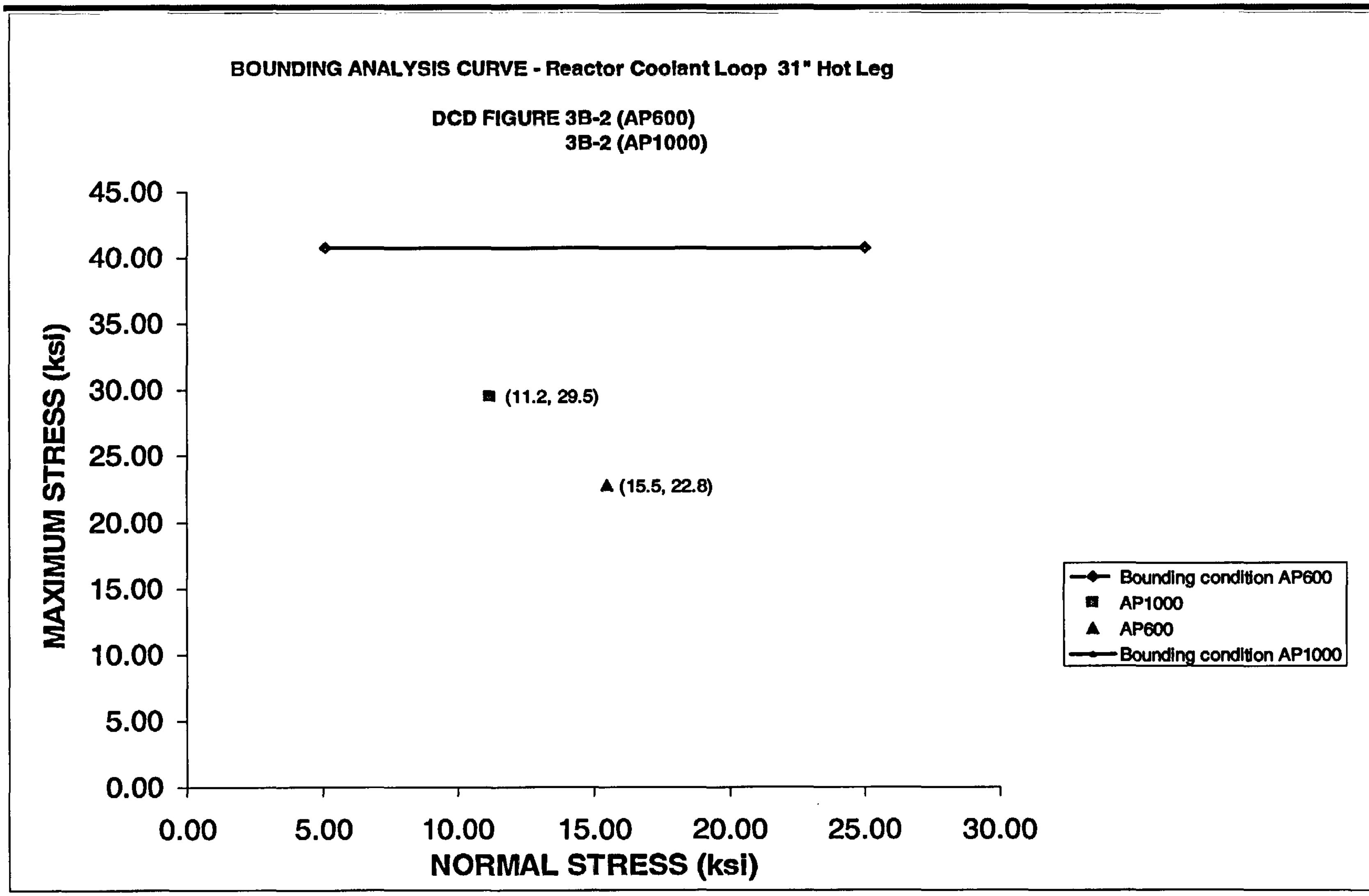


Figure 16 - Bounding Analysis Curve – Primary Loop Hot Leg – 31"

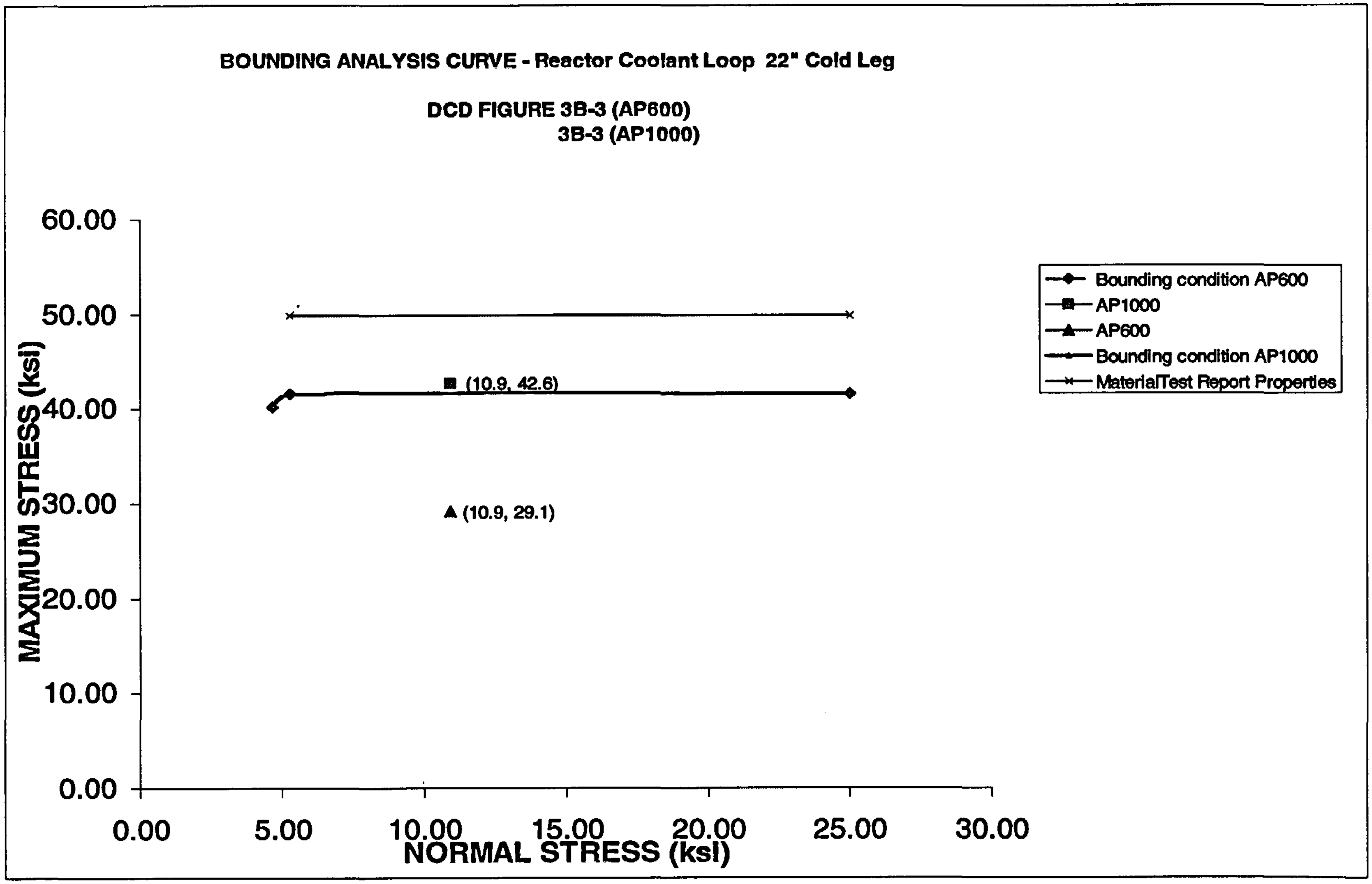


Figure 17 - Bounding Analysis Curve – Primary Loop Cold Leg – 22"

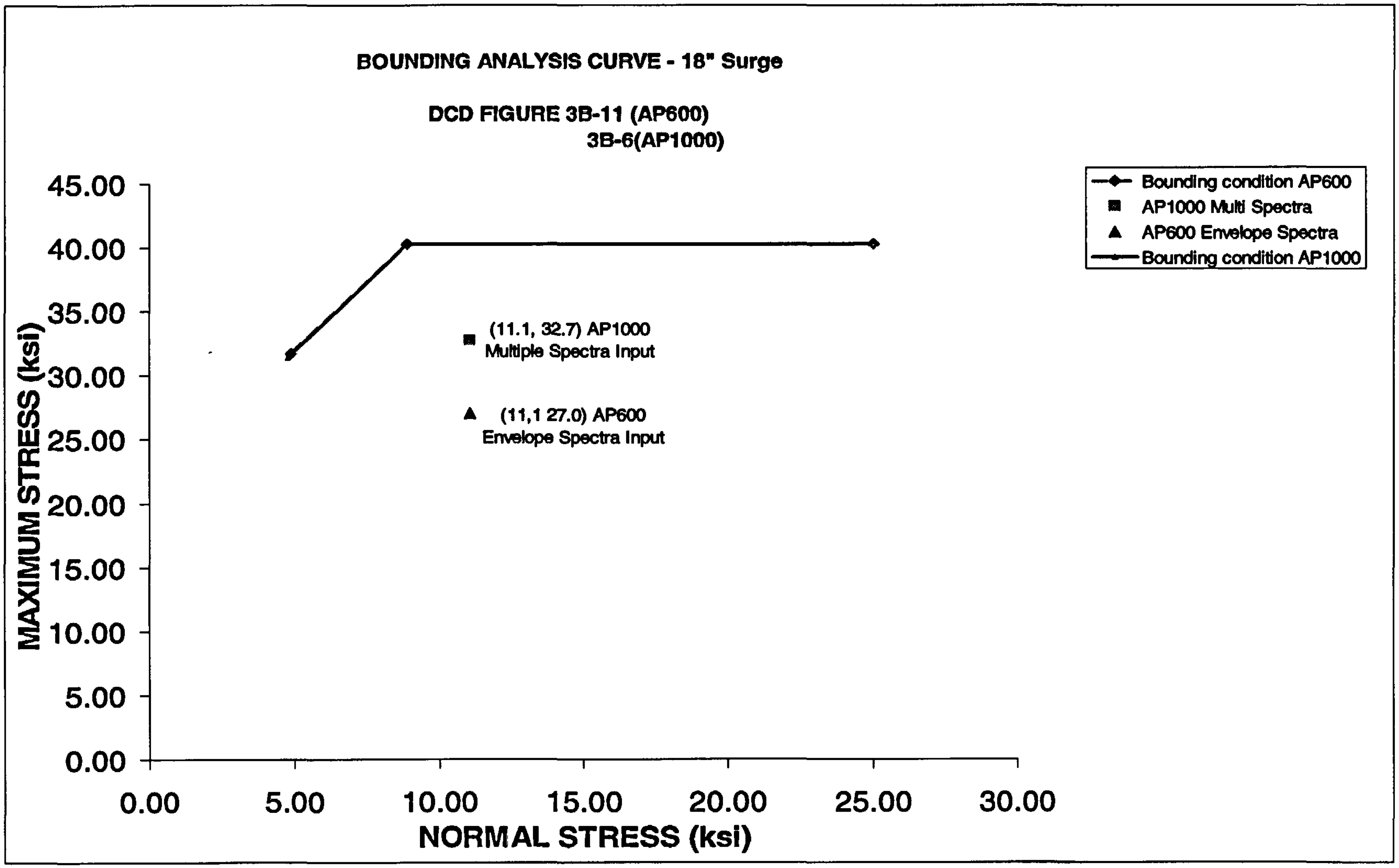


Figure 18 - Bounding Analysis Curve – Pressurizer Surgeline – 18"

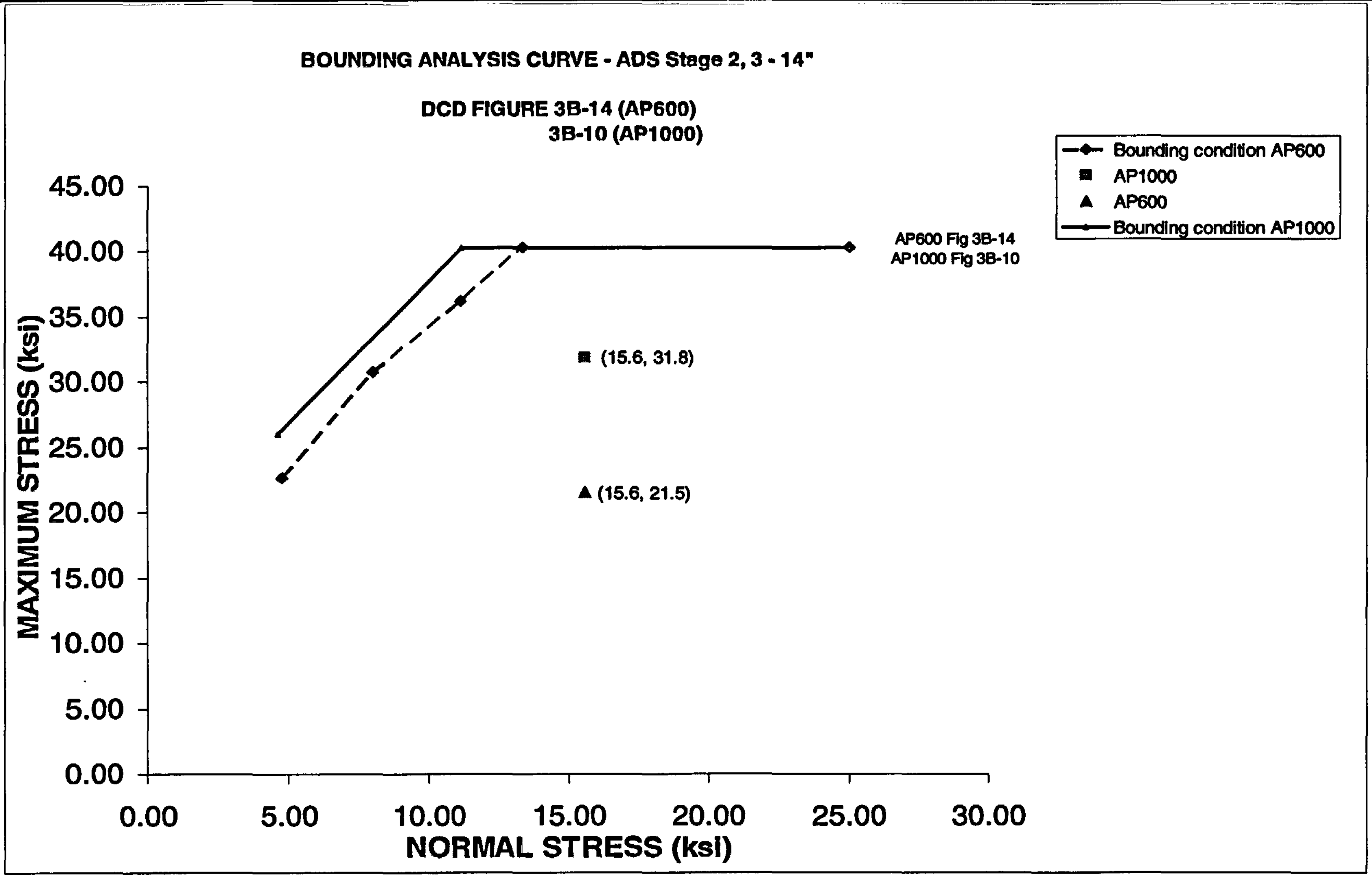


Figure 19 - Bounding Analysis Curve – ADS Stage 2 and 3 – 14"

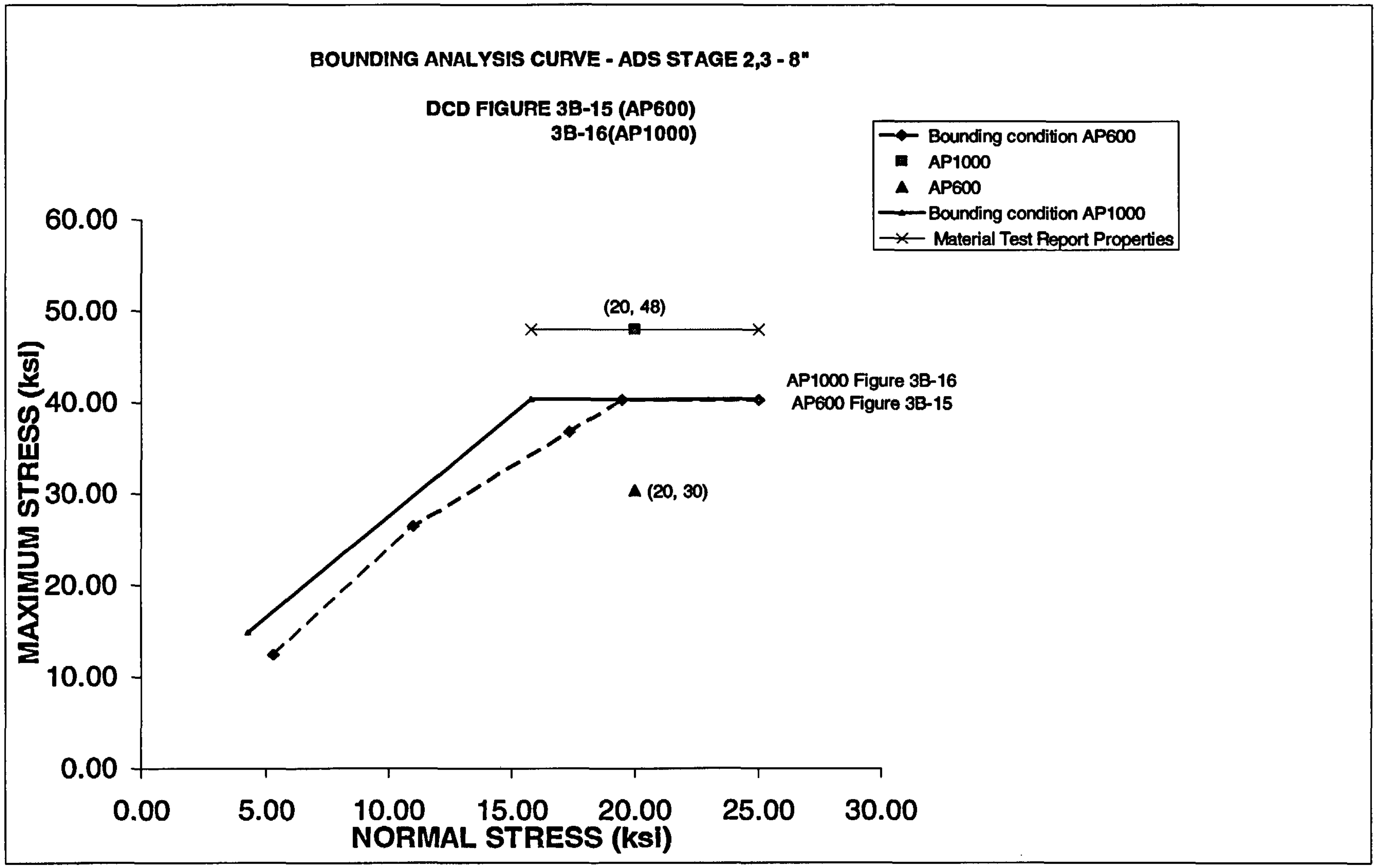


Figure 20 - Bounding Analysis Curve – ADS Stage 2 and 3 – 8"

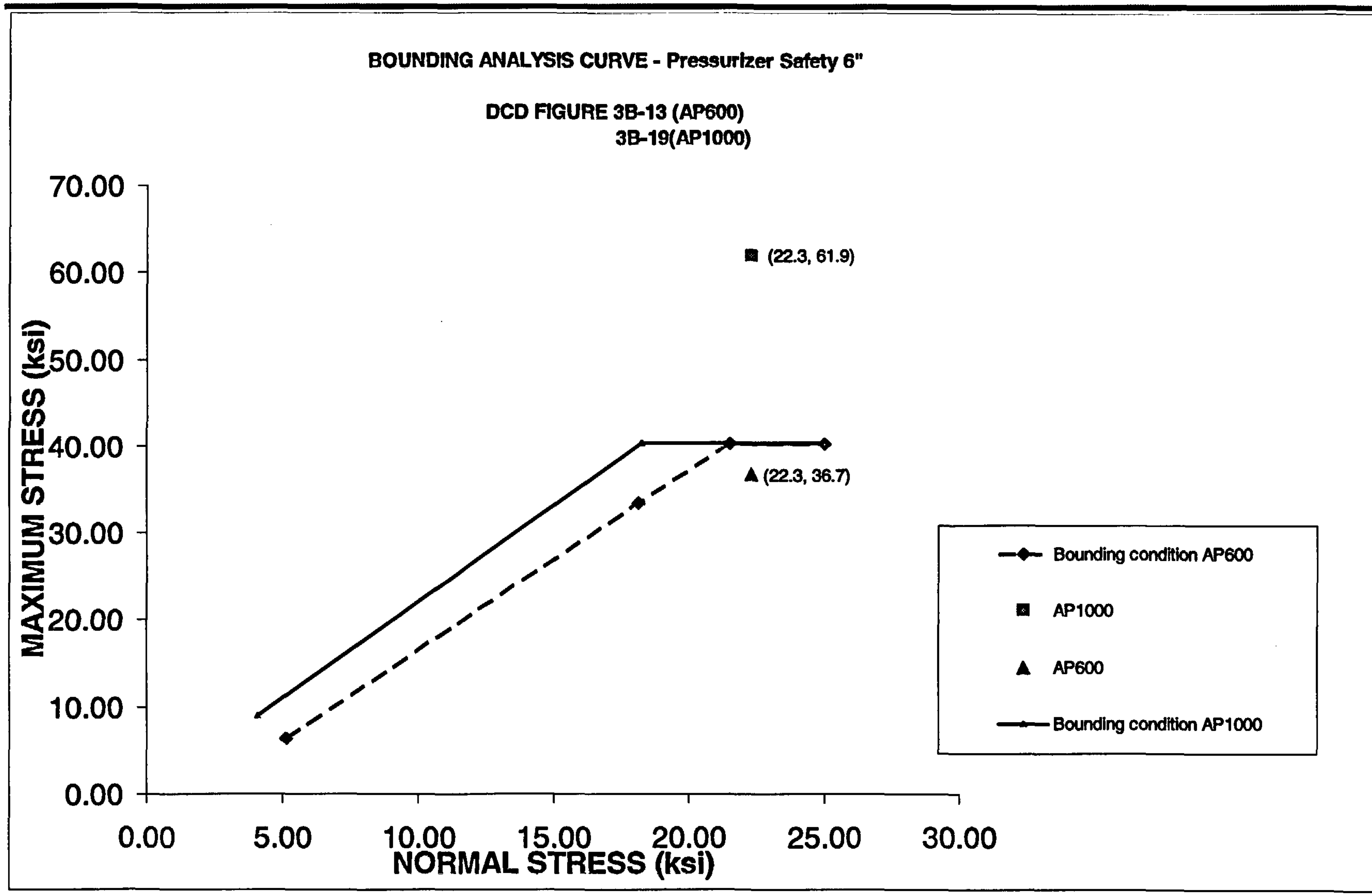


Figure 21 - Bounding Analysis Curve – Pressurizer Safety – 6”

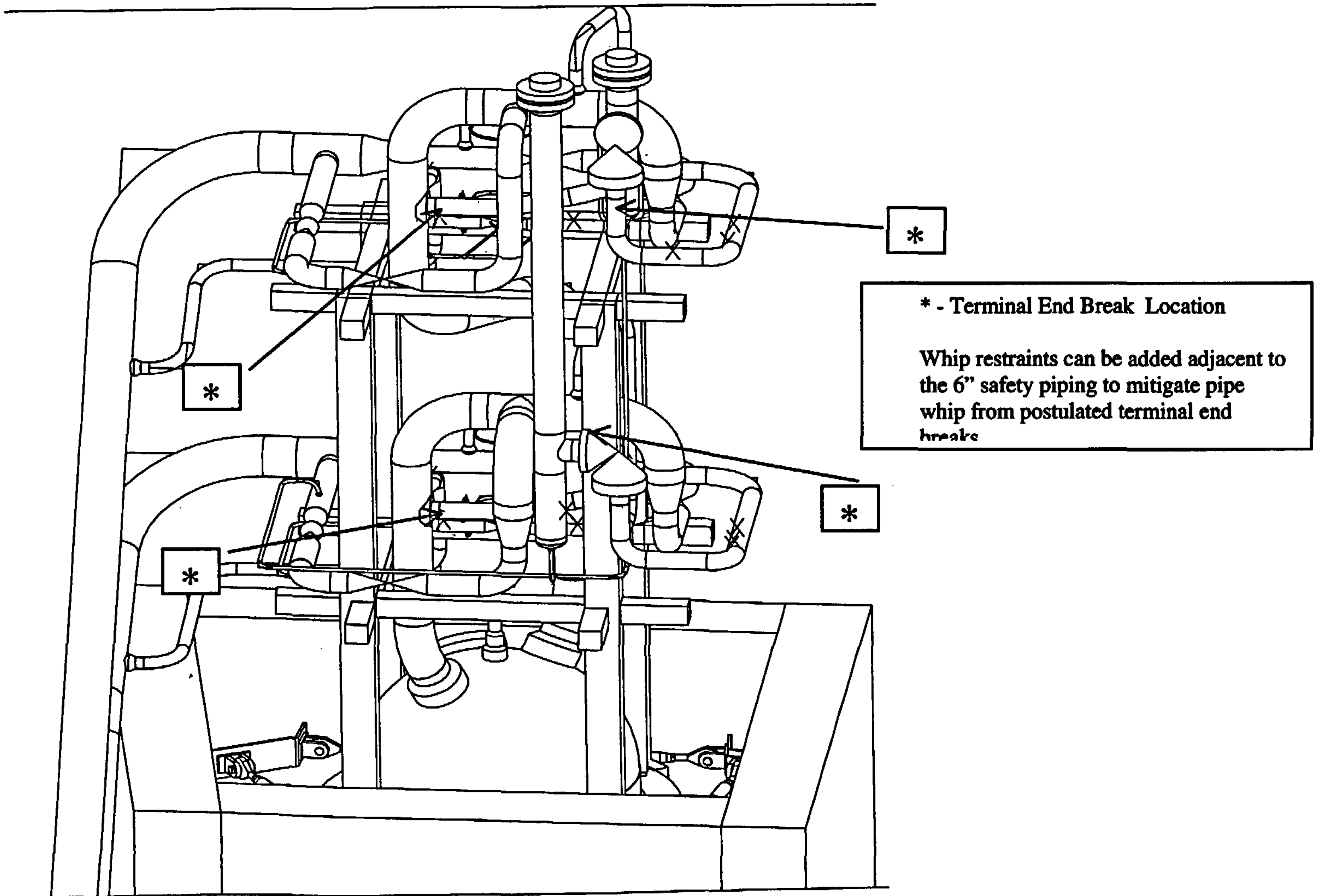
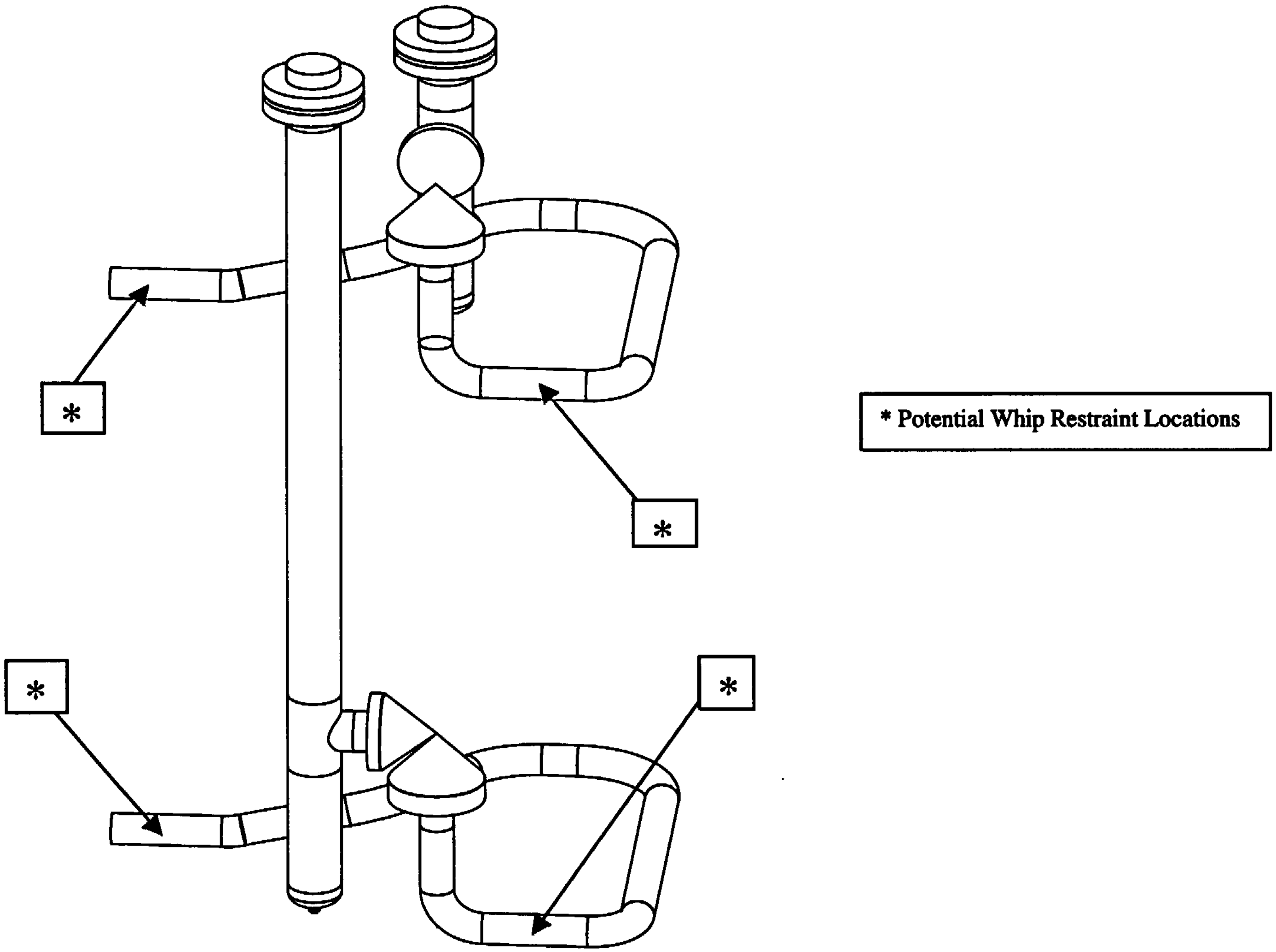


Figure 22 - Pressurizer Safety Valve Inlet Pipe Break Protection (Sheet 1 of 2)



-Figure 22 - Pressurizer Safety Valve Inlet Pipe Break Protection (Sheet 2 of 2)

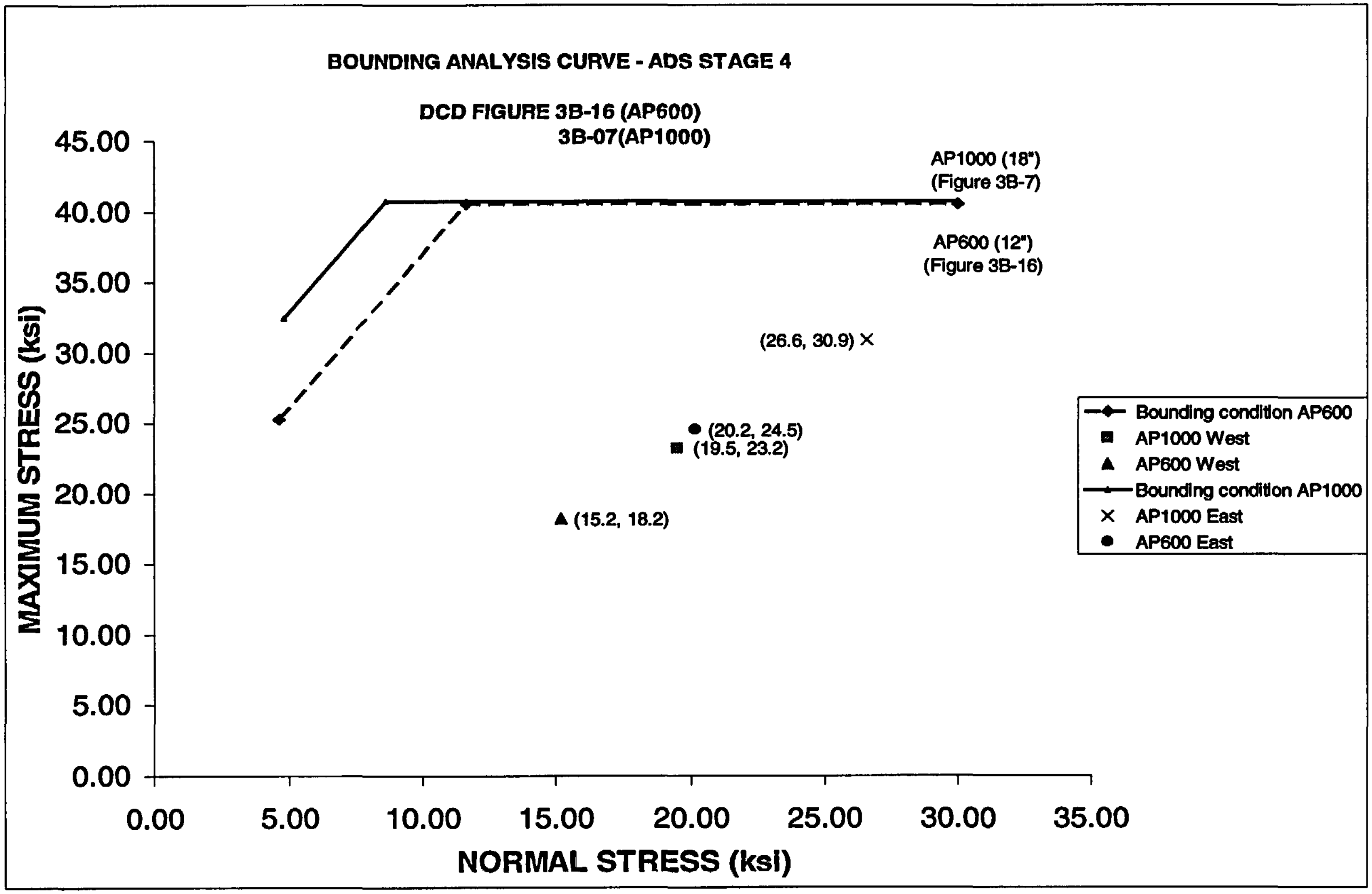


Figure 23 - Bounding Analysis Curve – ADS Stage 4 – 18"

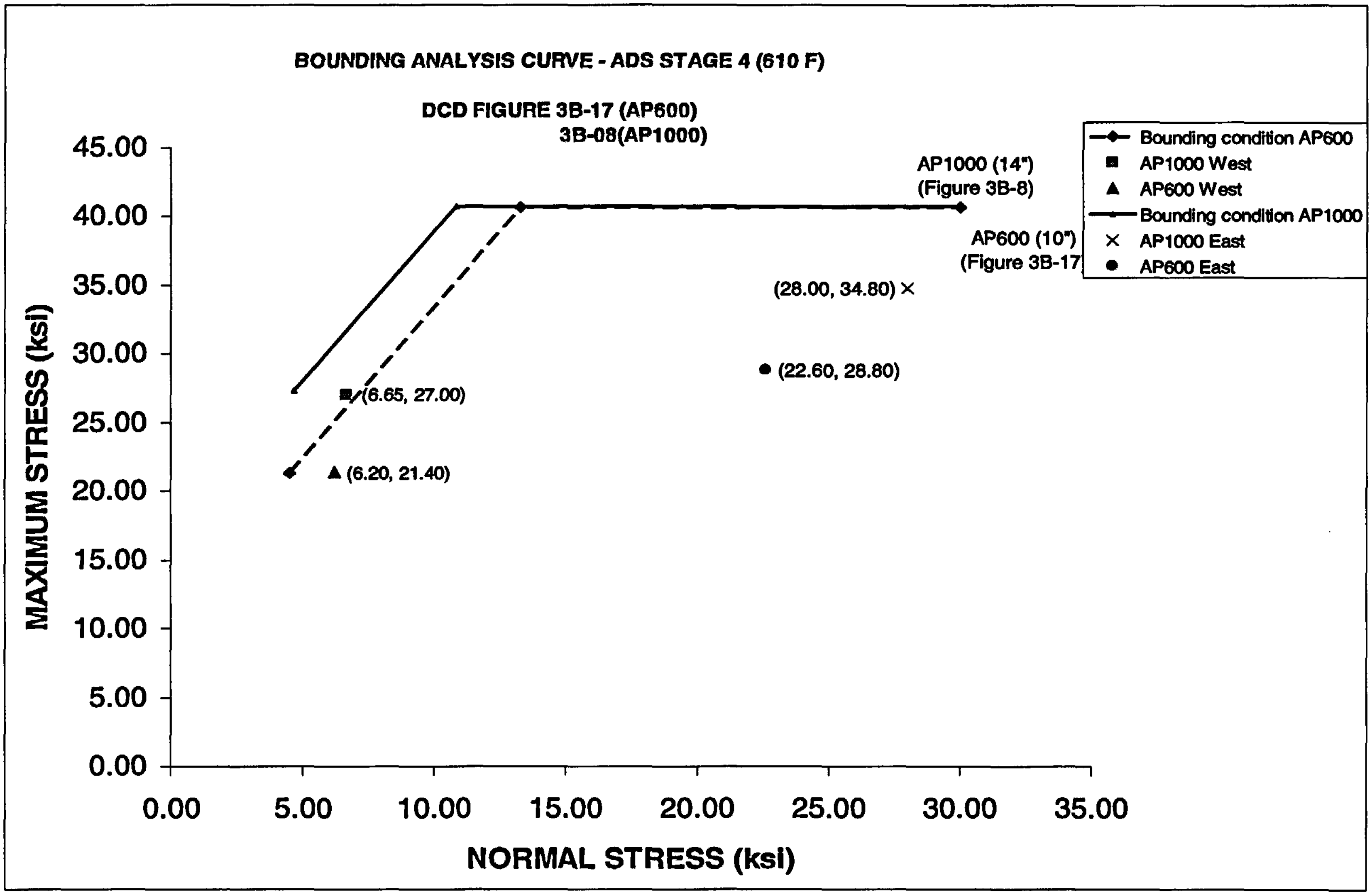


Figure 24 - Bounding Analysis Curve – ADS Stage 4 – 14" (610 °F)

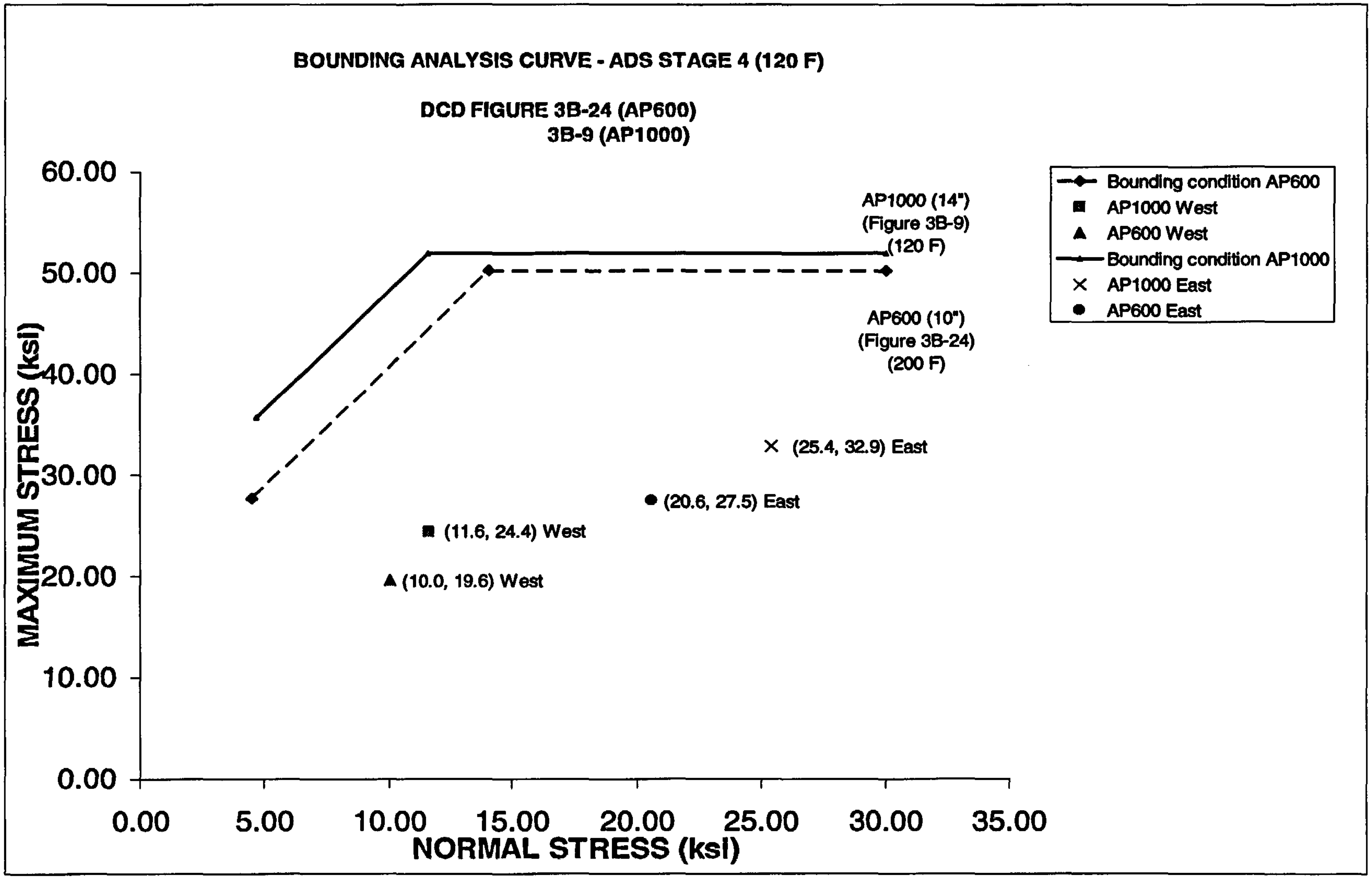


Figure 25 - Bounding Analysis Curve – ADS Stage 4 – 14" (120 °F)

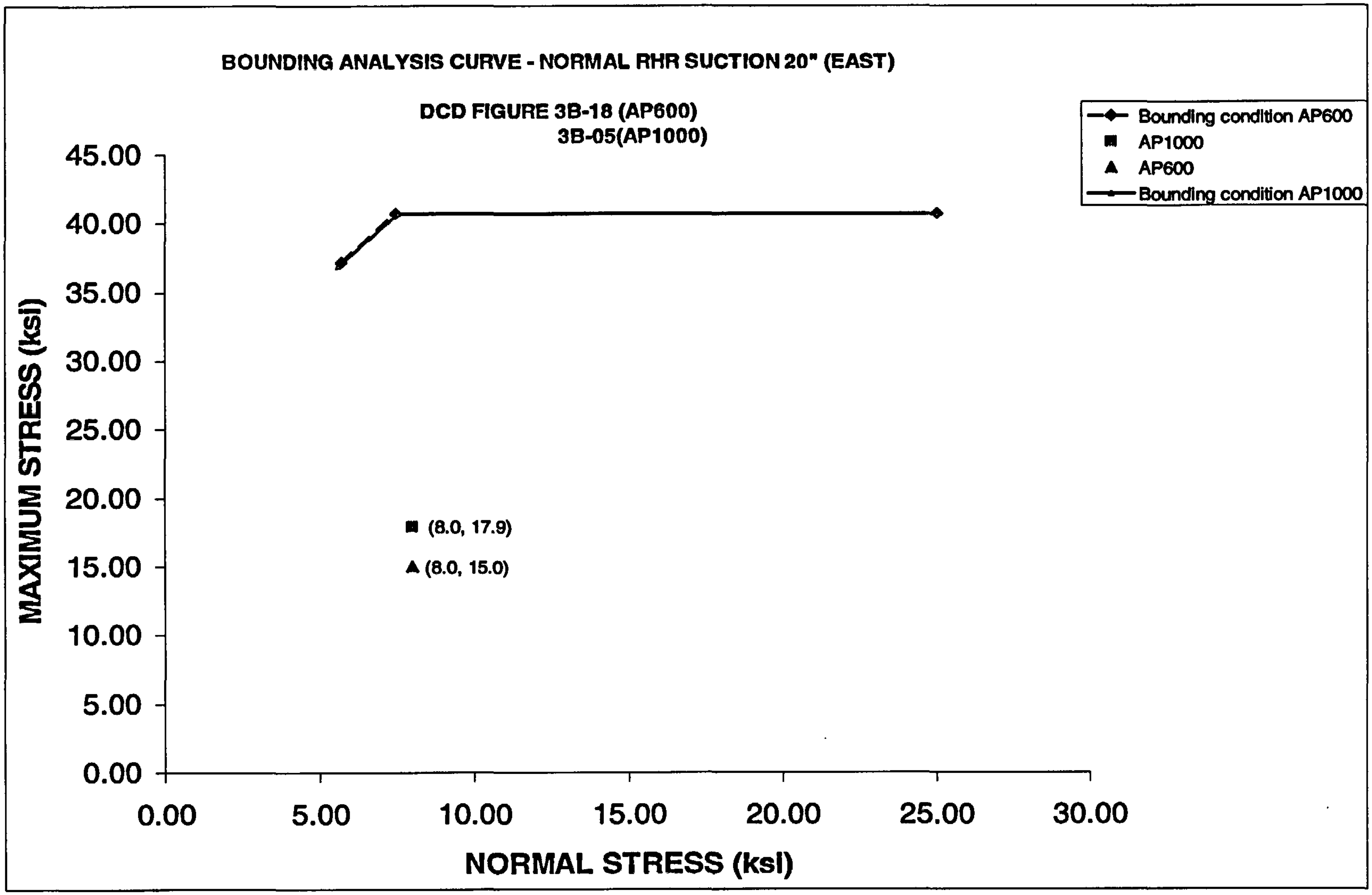


Figure 26 - Bounding Analysis Curve – Normal RHR Suction – 20”

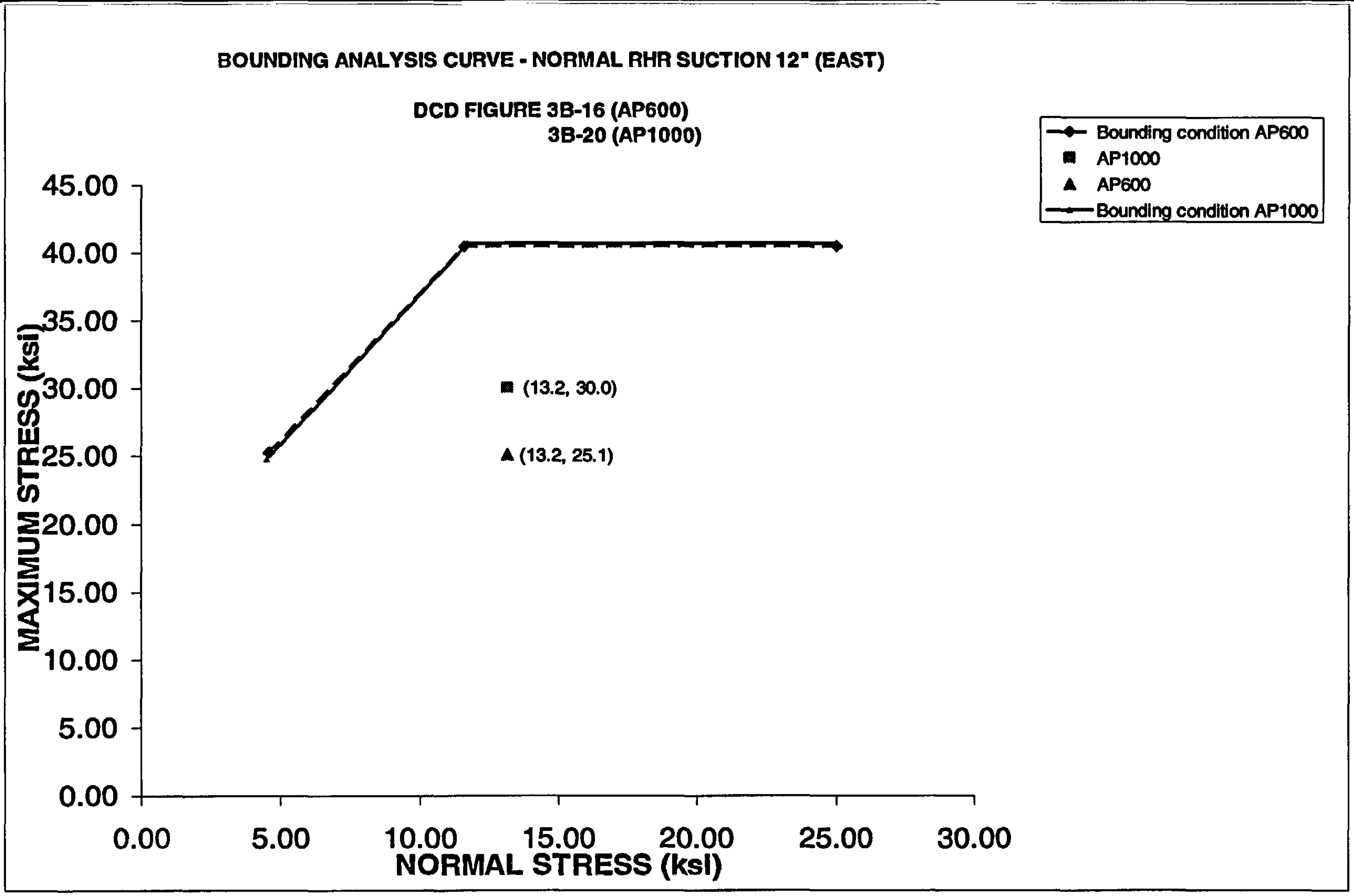


Figure 27 - Bounding Analysis Curve – Normal RHR Suction – 12"

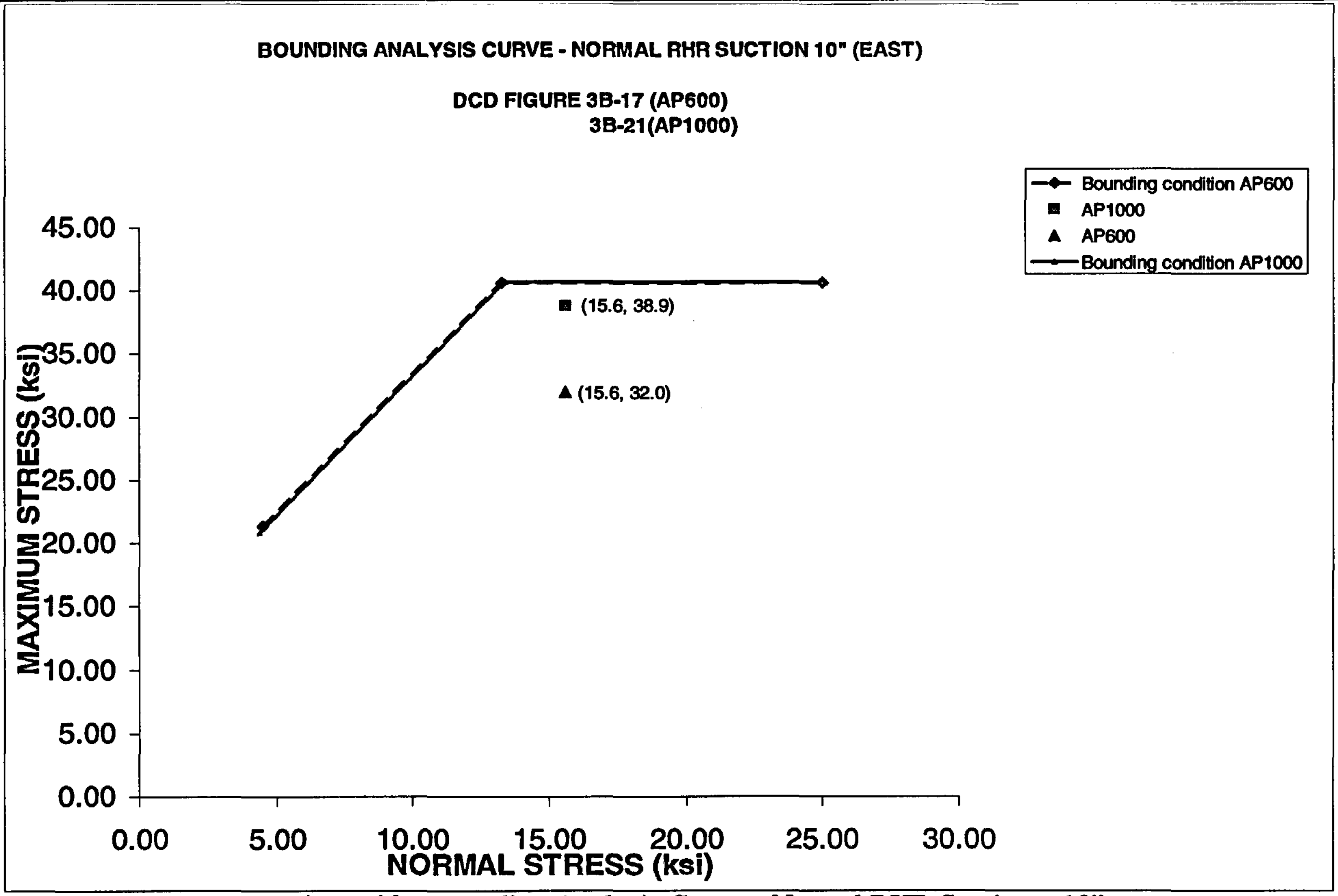


Figure 28 - Bounding Analysis Curve – Normal RHR Suction – 10”

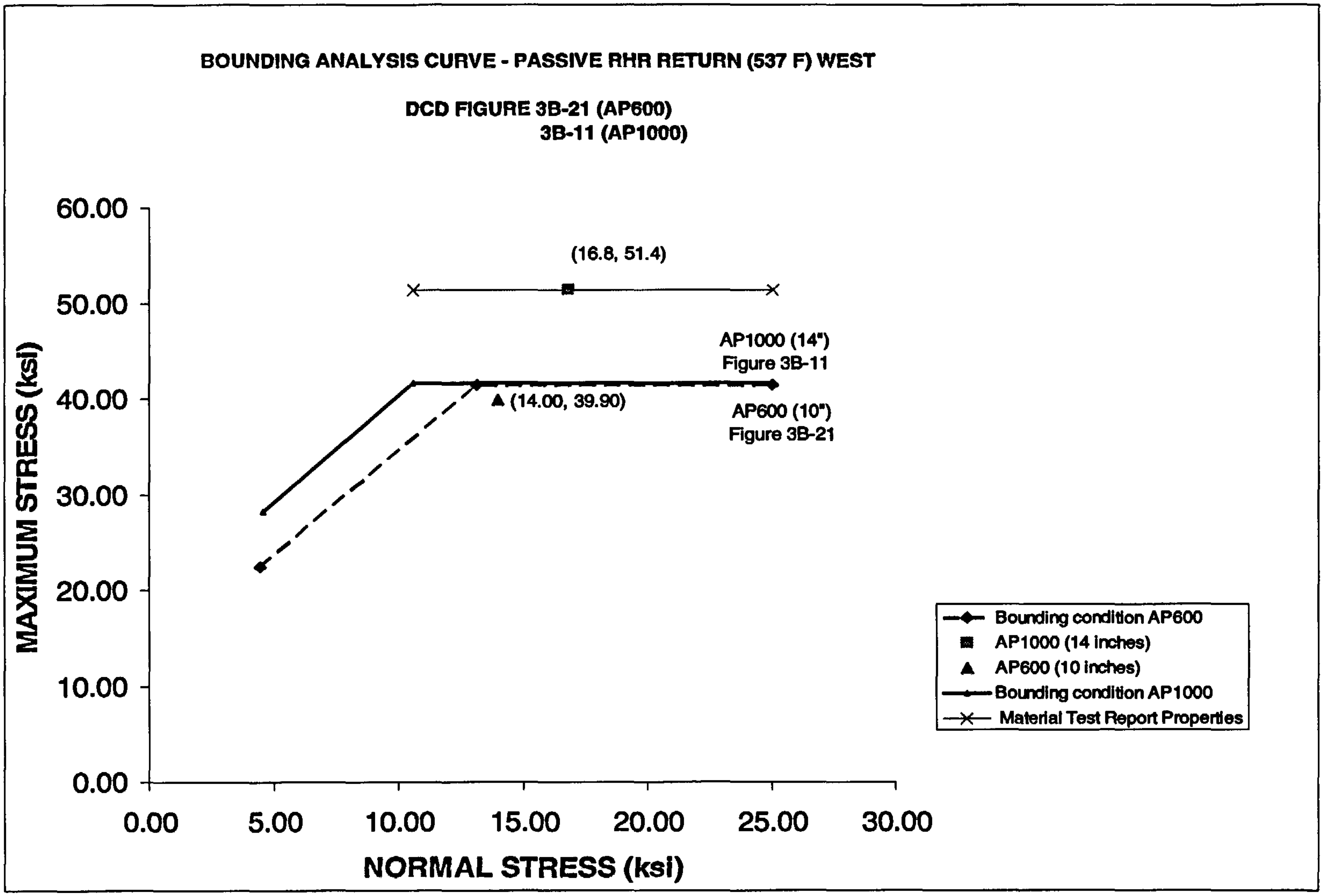


Figure 29 - Bounding Analysis Curve – Passive RHR Return – 14"

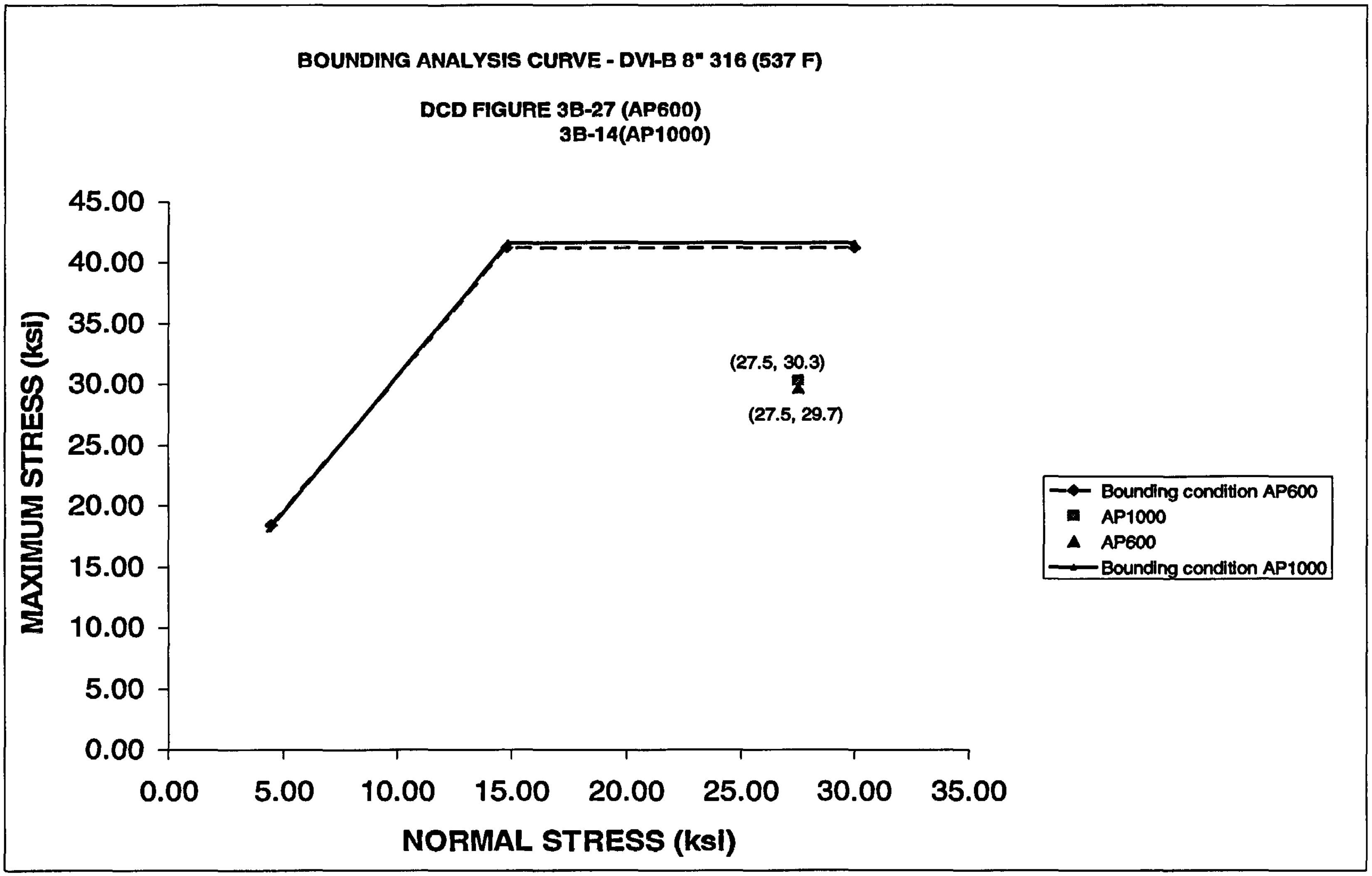


Figure 30 - Bounding Analysis Curve – DVI-B – 8" (316 SS, 537 °F)

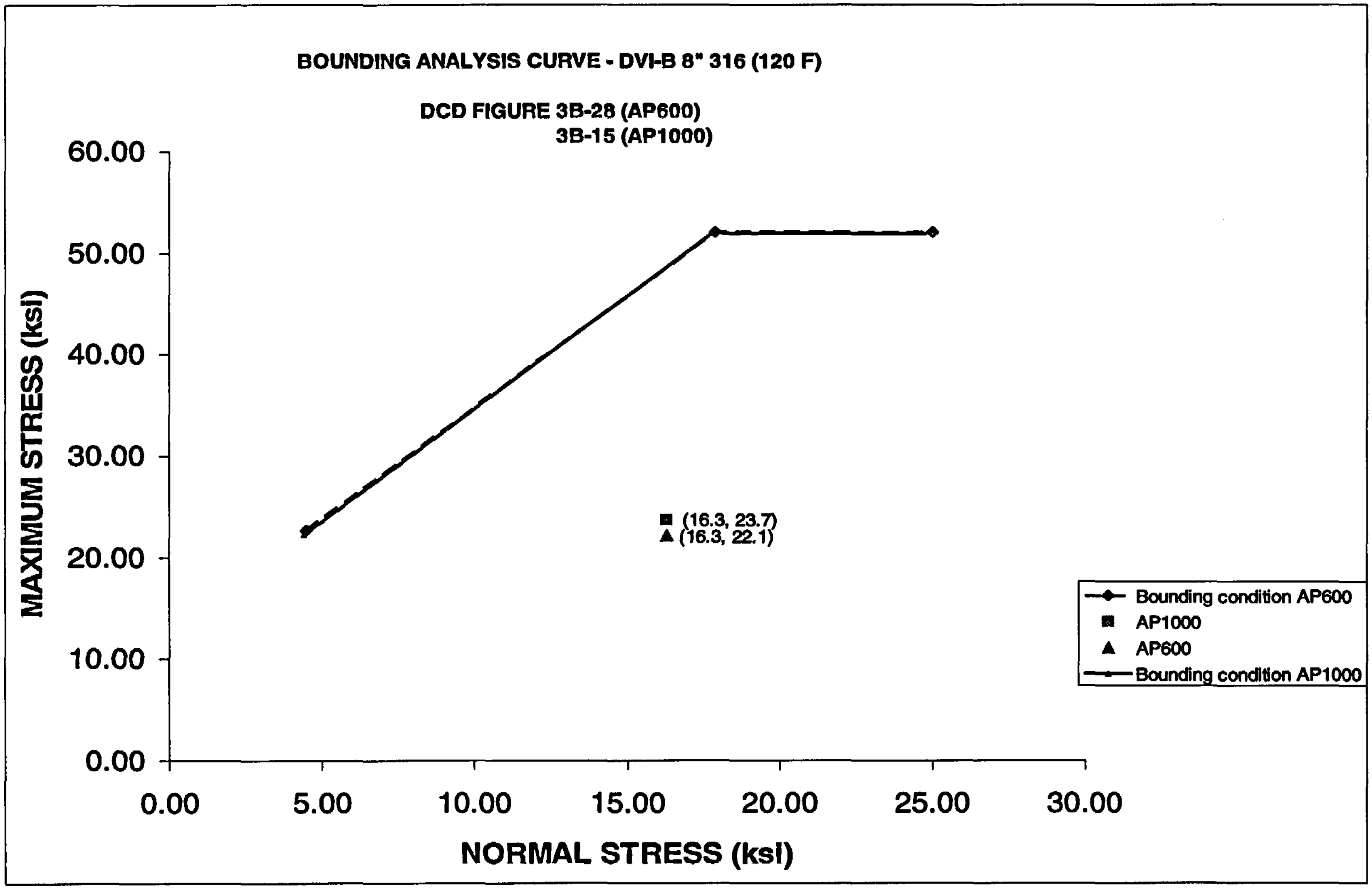


Figure 31 - Bounding Analysis Curve – DVI-B – 8" (316 SS, 120 °F)

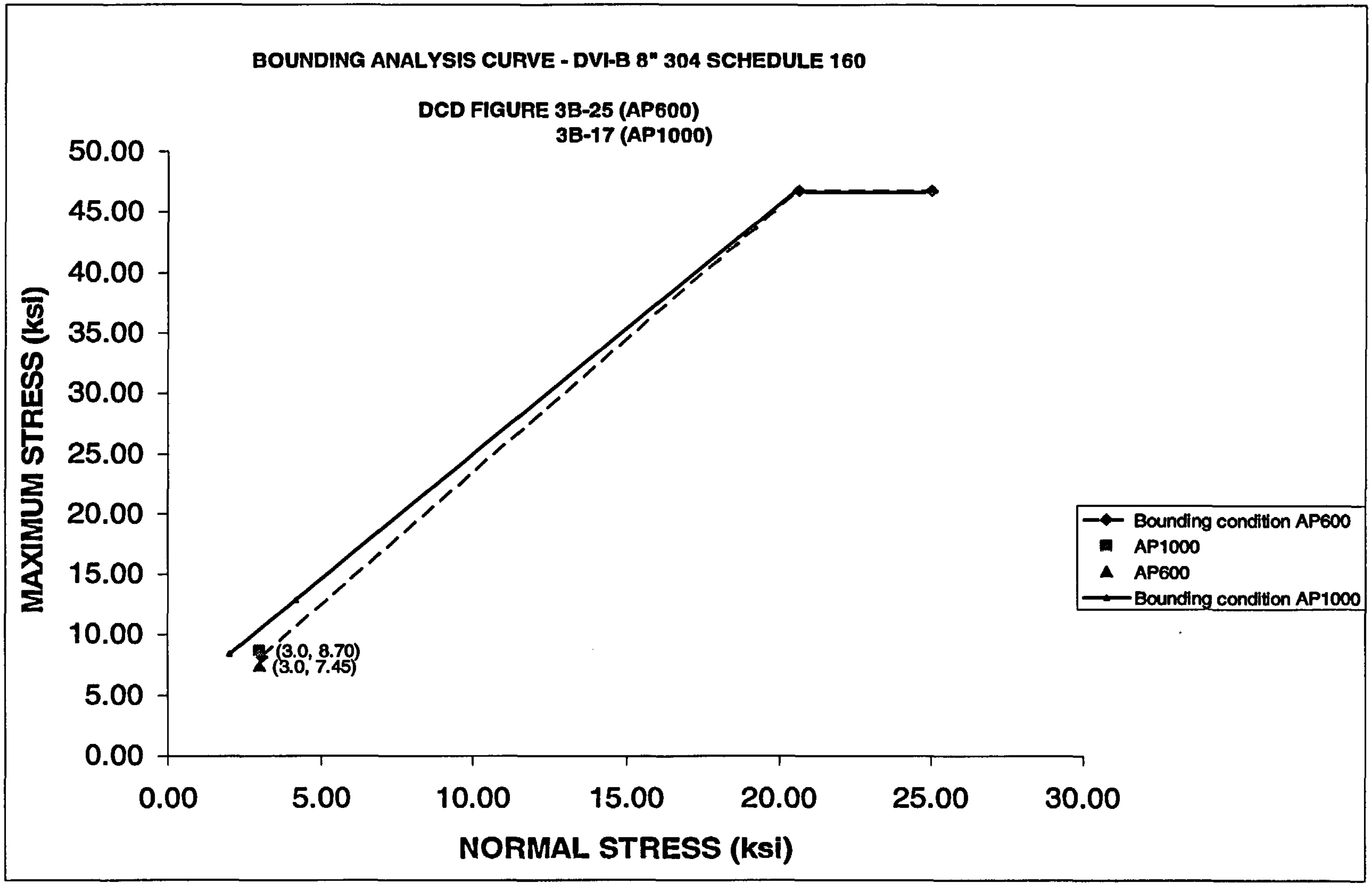


Figure 32 - Bounding Analysis Curve – DVI-B – 8" (304 SS)

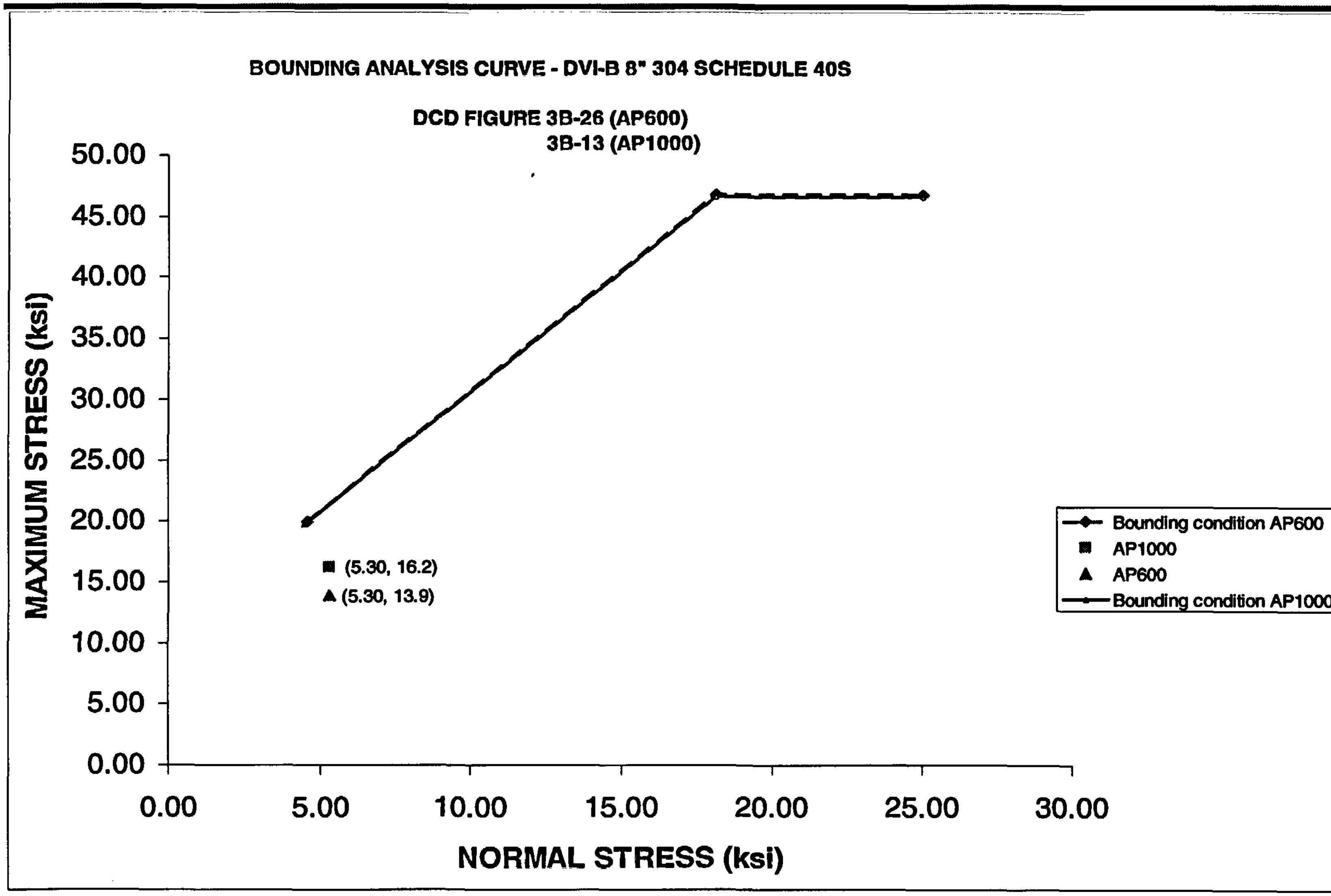


Figure 33 - Bounding Analysis Curve – DVI-B – 8" (Sch 40S)

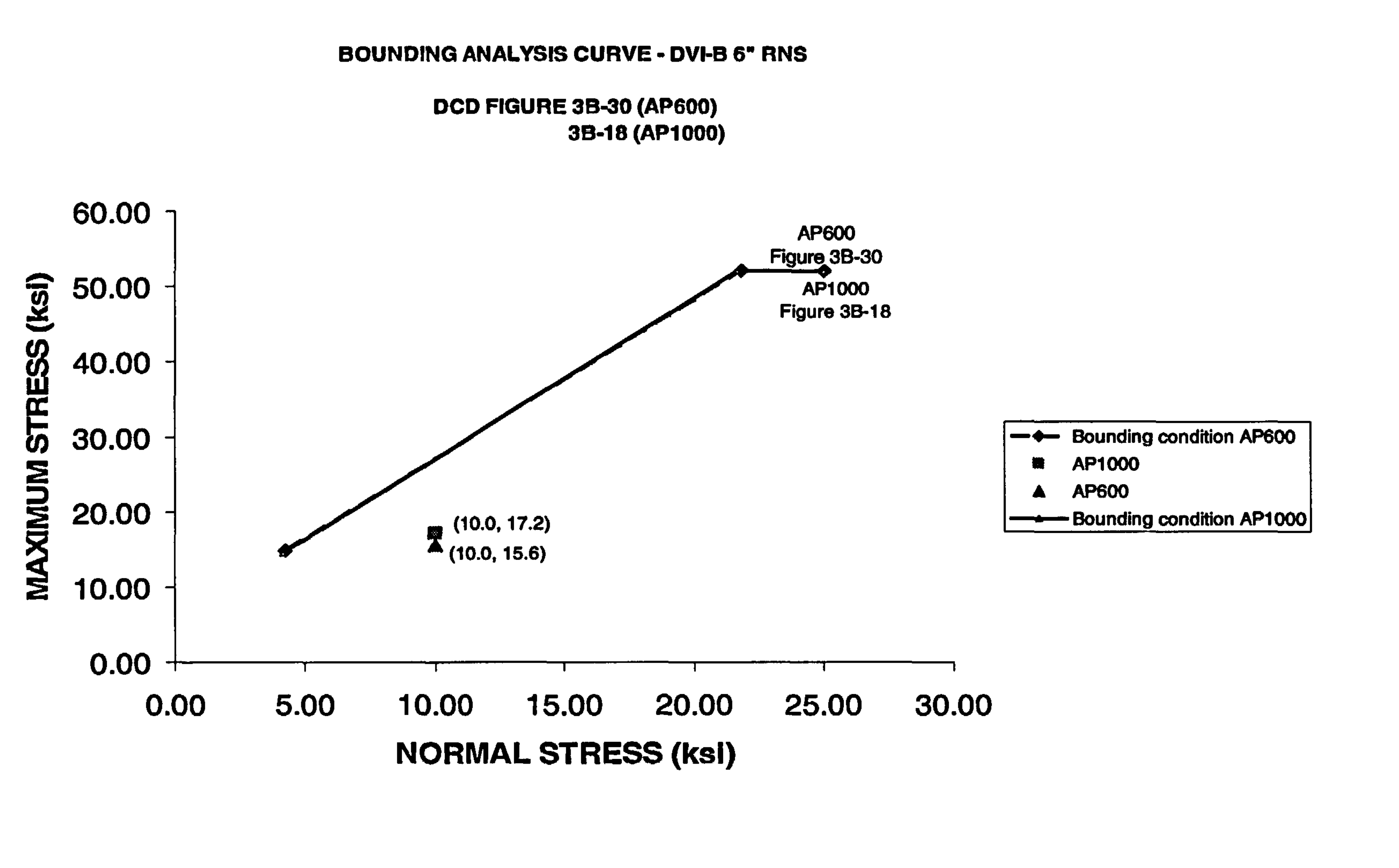


Figure 34 - Bounding Analysis Curve – DVI-B – 6" RNS

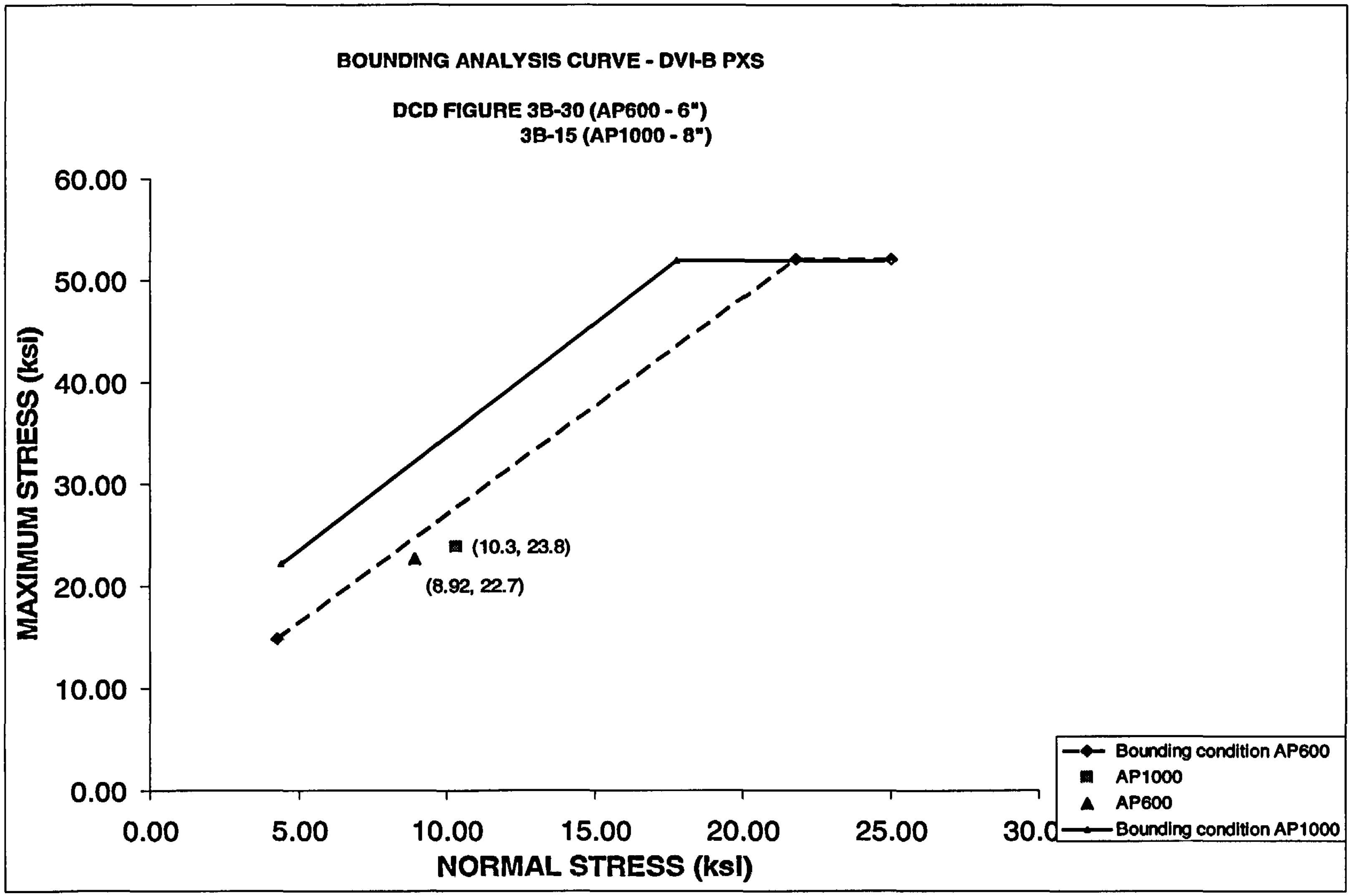


Figure 35 - Bounding Analysis Curve – DVI-B – 8" PXS

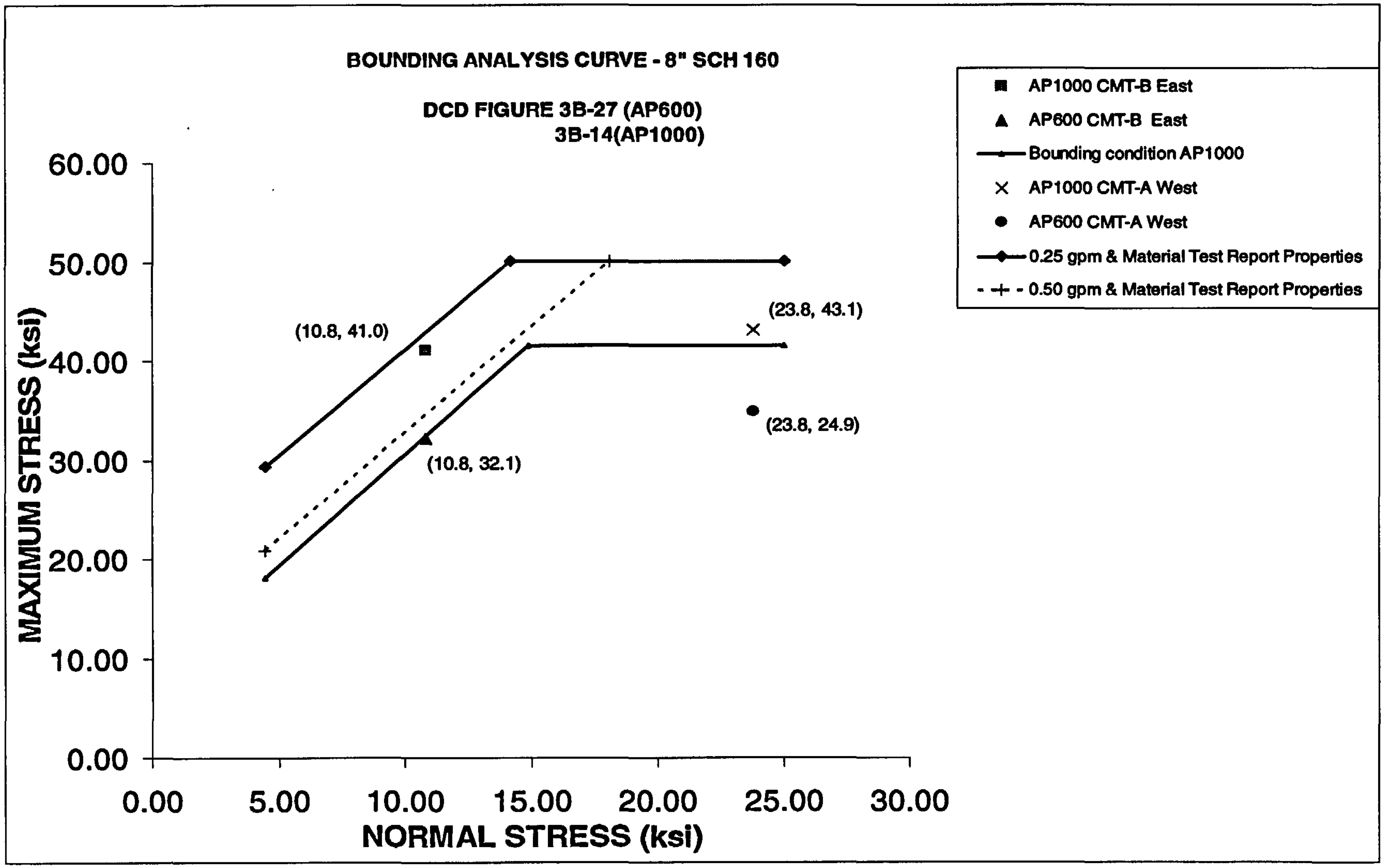


Figure 36 - Bounding Analysis Curve – CMT - 8”

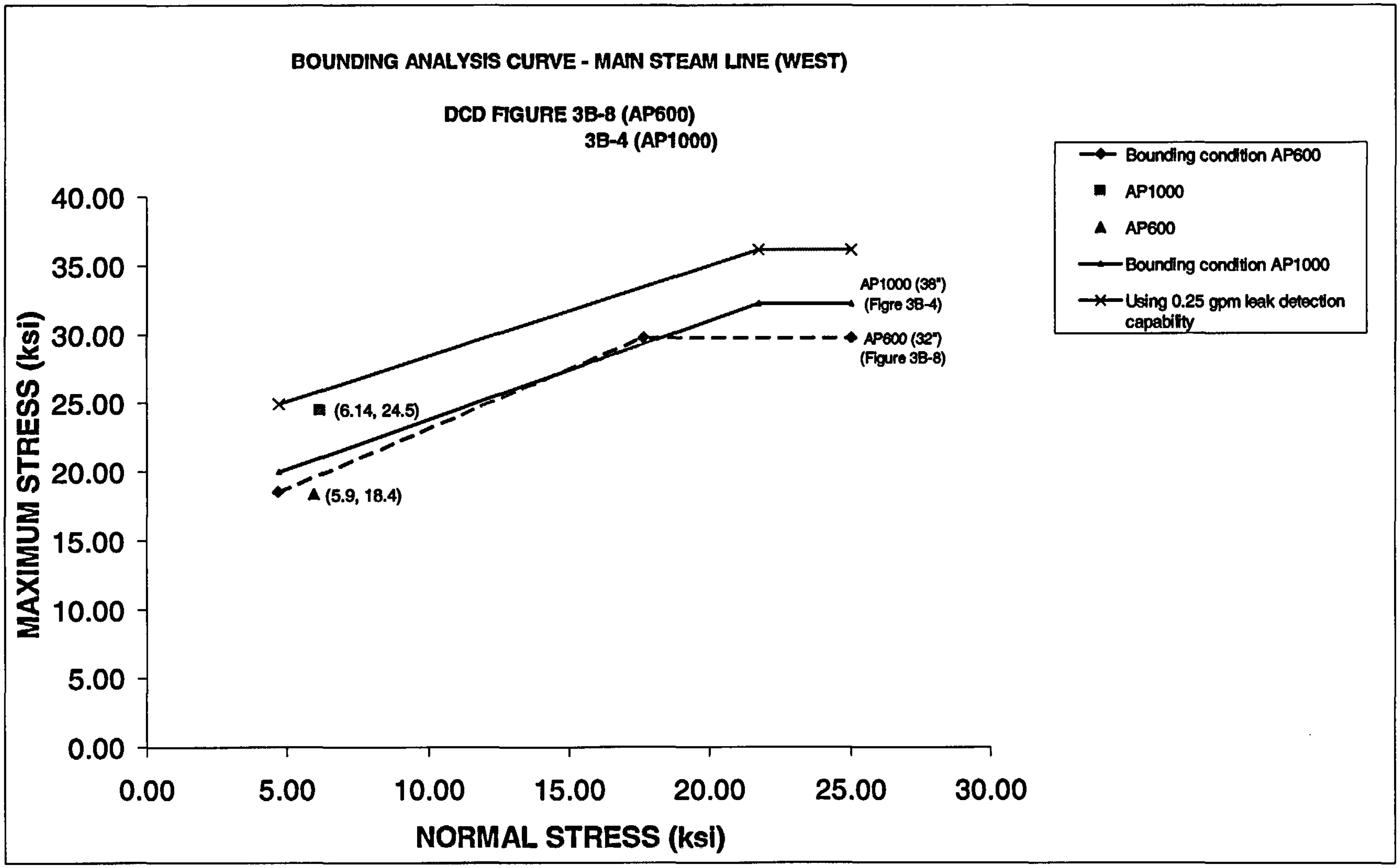


Figure 37 - Bounding Analysis Curve – Main Steam – West – 38”

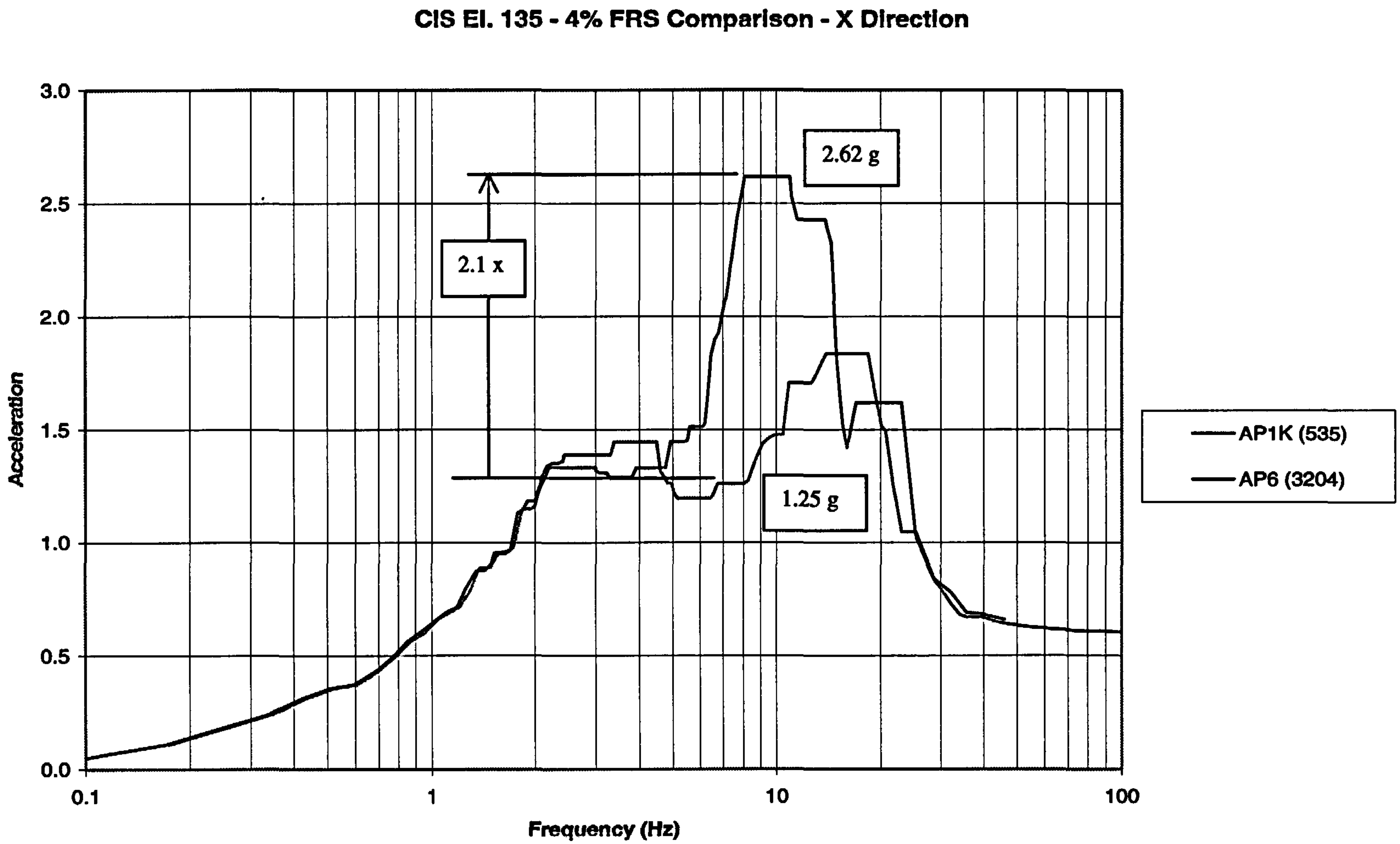


Figure 38 : Bounding Seismic Increase Factors -
Seismic Response Spectra, Steam Generator Support Elev. 135', (North-South) – 4th Stage ADS

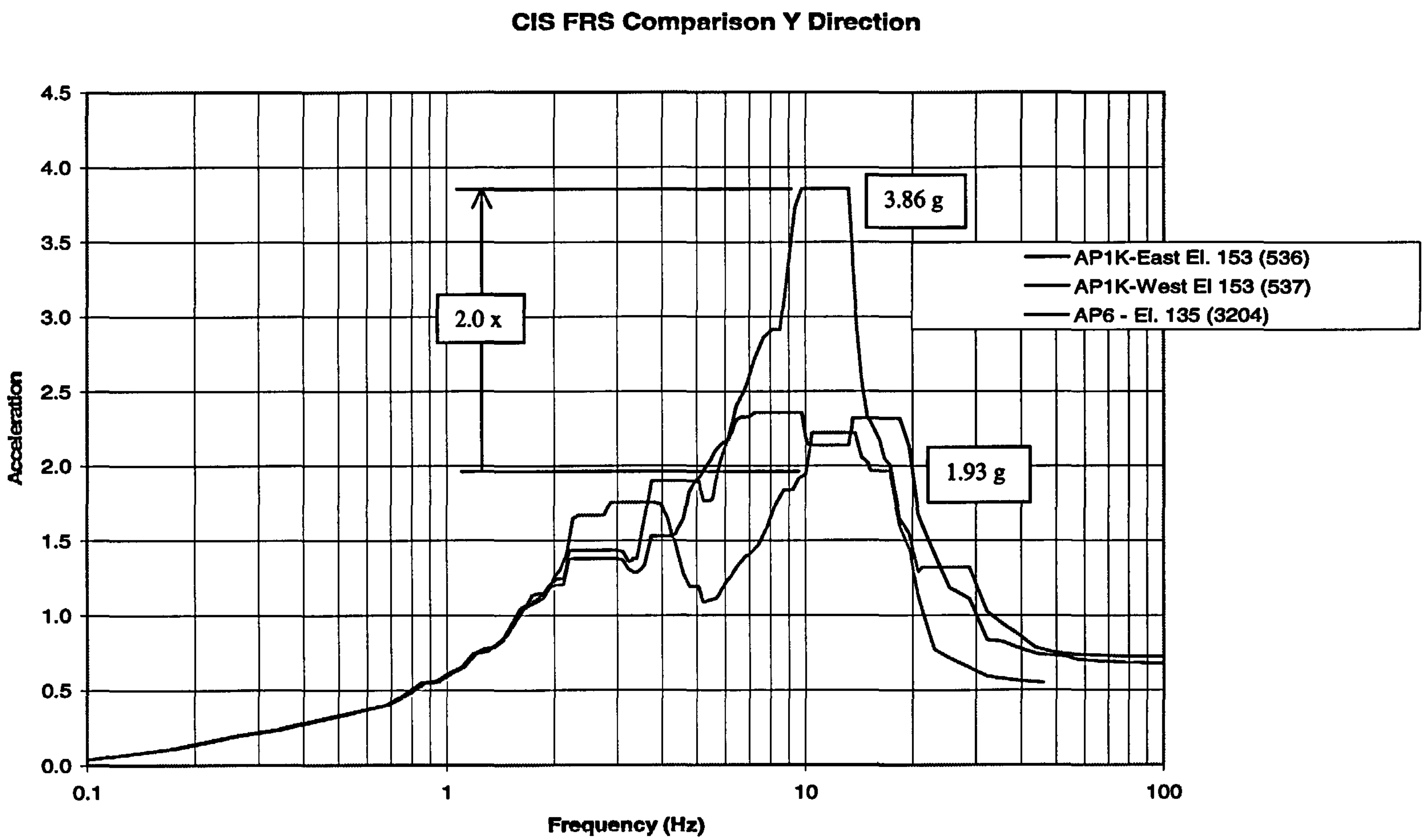


Figure 39 : Bounding Seismic Increase Factors
Seismic Response Spectra, Steam Generator Support Elev. 153' (East-West) – 4th Stage ADS

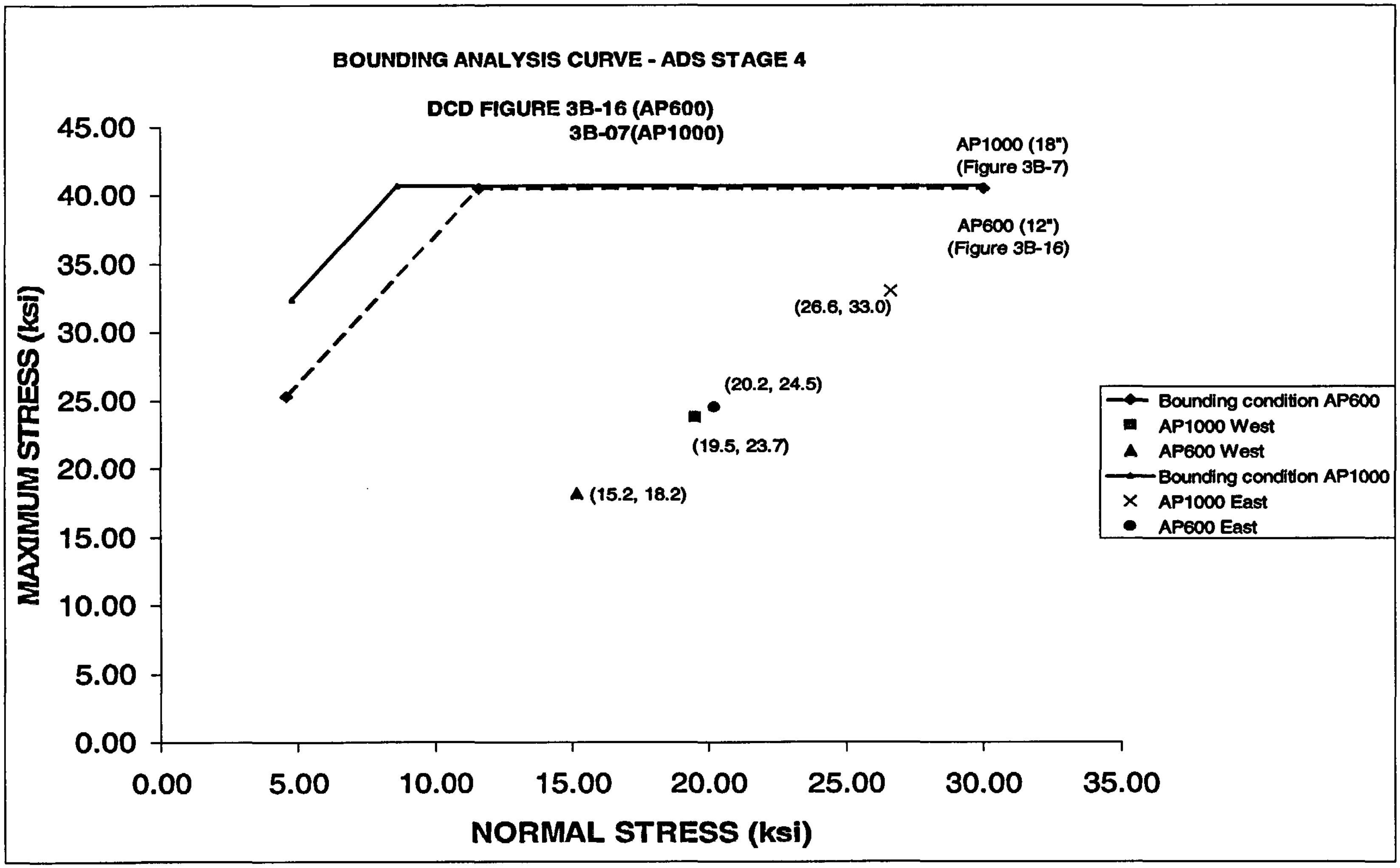


Figure 40 - Bounding Analysis Curve – ADS Stage 4 – 18" – Bounding Seismic Increase Factor

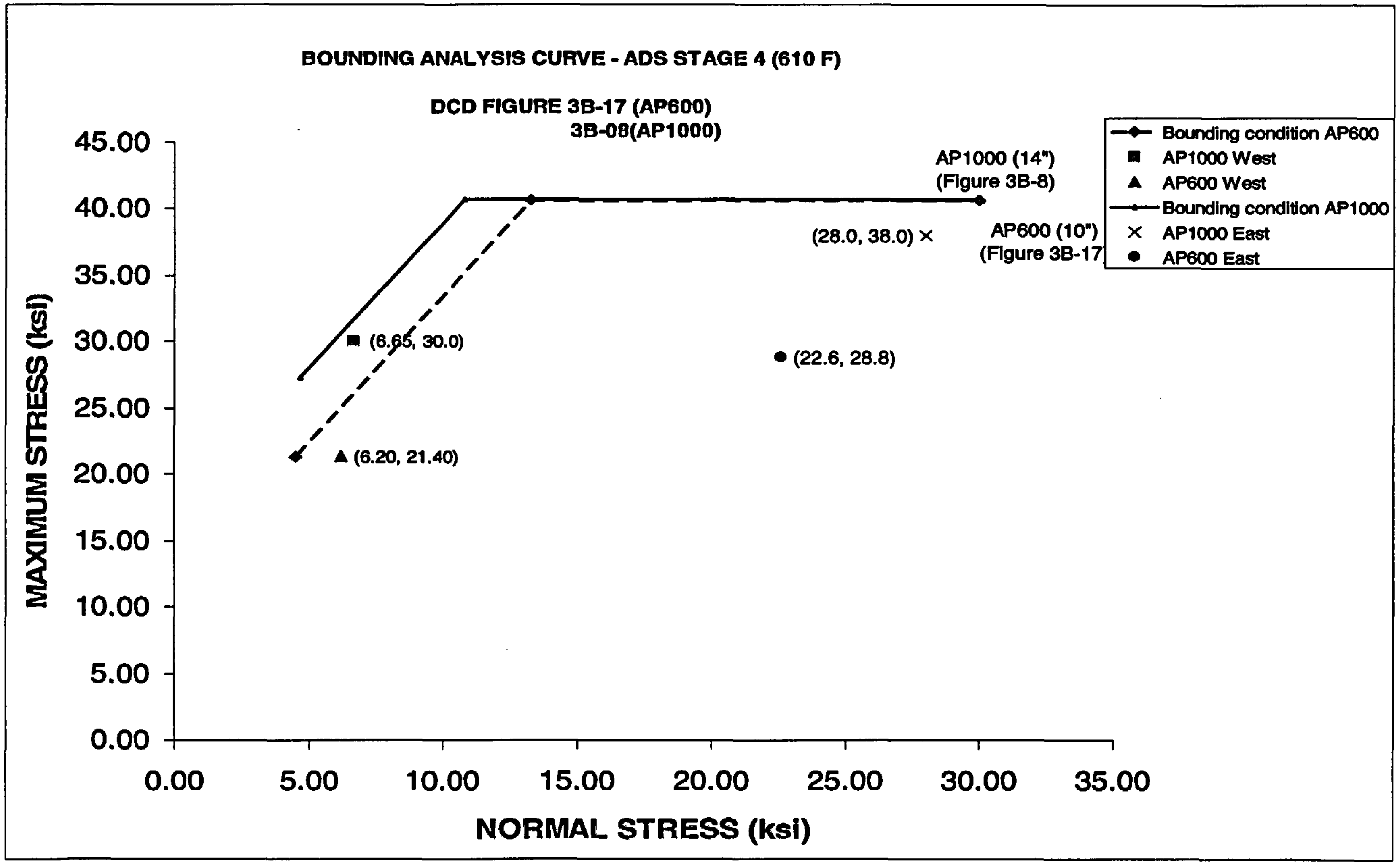


Figure 41 - Bounding Analysis Curve – ADS Stage 4 – 14" (610°F) – Bounding Seismic Increase Factor

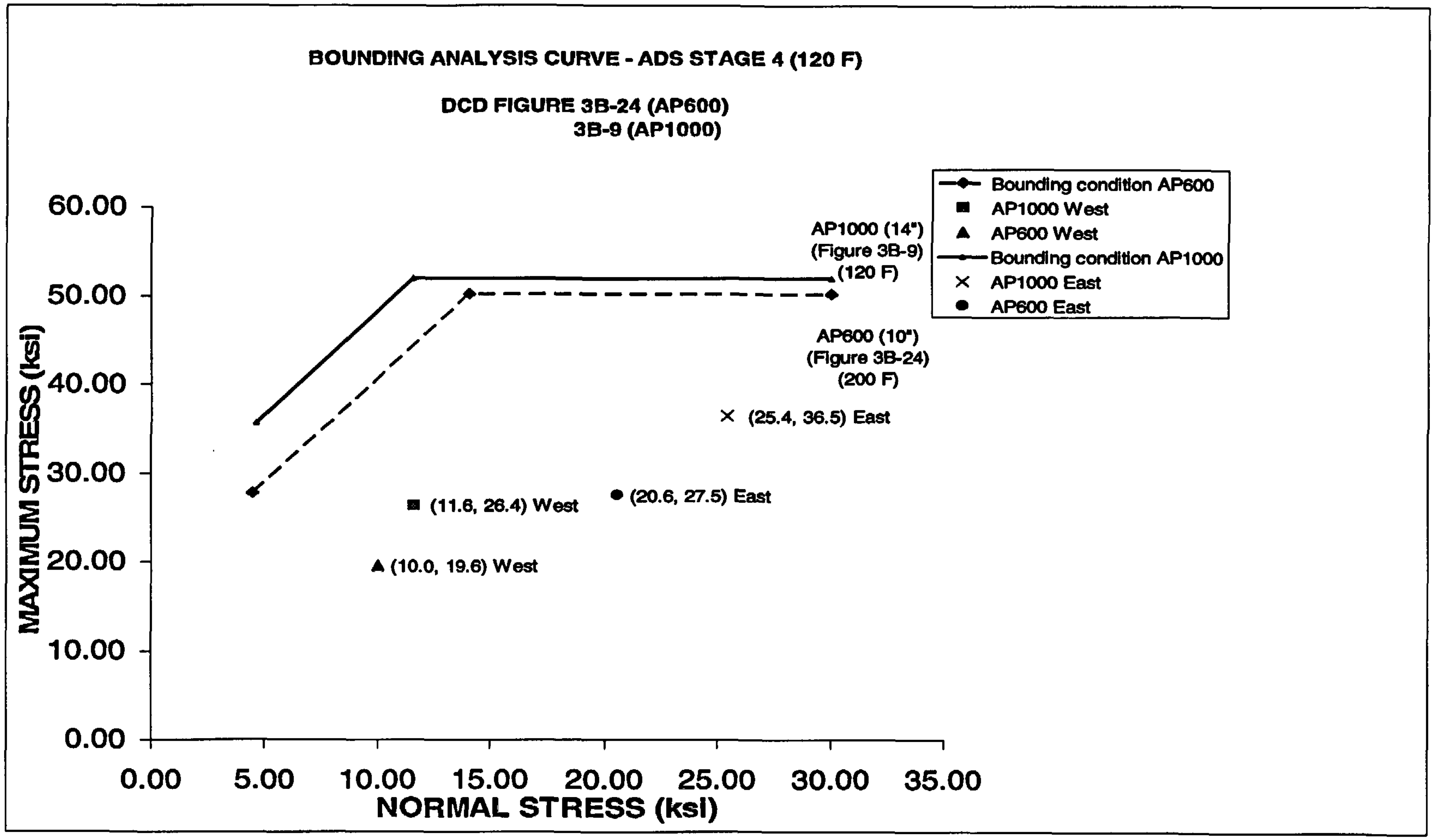


Figure 42 - Bounding Analysis Curve – ADS Stage 4 – 14" (120°F) – Bounding Seismic Increase Factor

APPENDIX A

Summary of Sample Certified Material Test Reports Review			
	Room temperature CMTRs properties		
Plant	Material	Yield Strength (psi)	Ultimate Strength (psi)
Plant A	A376/TP316	46800	93800
Aux. lines	A376/TP316	48000	86400
	A376/TP316	45600	87900
	A376/TP316	41300	83200
	A376/TP316	38600	82600
	A376/TP316	44900	84000
Plant B	A376/TP316	59100	84900
Aux. lines	A376/TP316	52100	87400
	A376/TP316	51900	85400
	A376/TP316	48400	84900
	A376/TP316	59100	84900
	A376/TP316	47400	81100
	A376/TP316	47400	81100
	A376/TP316	59100	84900
	A376/TP316	48400	84900
	A376/TP316	48400	84900
	A376/TP316	59100	84900
	A376/TP316	45200	87600
	A376/TP316	51900	85400
	A376/TP316	59100	84900
	A376/TP316	59100	84900
	A376/TP316	59100	84900
	A376/TP316	45200	87600
	A376/TP316	48400	84900
	A376/TP316	47400	81100
	A376/TP316	45200	87600
	A376/TP316	51900	85400
	A376/TP316	47400	81100
	A376/TP316	47400	81100
	A376/TP316	47400	81100
	A376/TP316	59100	84900
	A376/TP316	59100	84900
	A376/TP316	51900	85400
	A376/TP316	52100	87400

Summary of Sample Certified Material Test Reports Review			
	Room temperature CMTRs properties		
Plant	Material	Yield Strength (psi)	Ultimate Strength (psi)
	A376/TP316	47400	81100
	A376/TP316	59100	84900
	A376/TP316	47400	81100
	A376/TP316	51900	85400
	A376/TP316	59100	84900
	A376/TP316	59100	84900
	A376/TP316	48400	84900
	A376/TP316	52100	87400
	A376/TP316	59100	84900
	A376/TP316	47400	81100
	A376/TP316	39200	84200
	A376/TP316	42200	84900
	A376/TP316	39200	84200
	A376/TP316	52100	87400
	A376/TP316	52100	87400
	A376/TP316	52100	87400
	A376/TP316	45200	87600
	A376/TP316	52100	87400
	A376/TP316	51900	85400
	A376/TP316	48400	84900
Plant C	A376/TP316	43300	85600
Aux. lines	A376/TP316	42700	88200
	A376/TP316	38100	82600
	A376/TP316	43300	85600
	A376/TP316	42700	88200
	A376/TP316	38100	82600
	A376/TP316	40100	83000
	A376/TP316	38100	82600
	A376/TP316	43300	87800
	A376/TP316	44100	88600
	A376/TP316	40100	83000
	A376/TP316	40500	84600
	A376/TP316	44500	81400
	A376/TP316	50250	87400
	A376/TP316	42400	84900
	A376/TP316	42100	89000
	A376/TP316	39700	86200
	A376/TP316	44500	81400

Summary of Sample Certified Material Test Reports Review			
	Room temperature CMTRs properties		
Plant	Material	Yield Strength (psi)	Ultimate Strength (psi)
	A376/TP316	44500	81400
Plant D	A376/TP316	42700	88200
Aux. lines	A376/TP316	38100	82600
	A376/TP316	42700	88200
	A376/TP316	38100	82600
	A376/TP316	42700	88200
	A376/TP316	46700	92600
	A376/TP316	42700	88200
	A376/TP316	42050	82500
	A376/TP316	44600	85100
	A376/TP316	49100	81200
	A376/TP316	41150	80900
	A376/TP316	49100	81200
	A376/TP316	41150	80900
	A376/TP316	42100	82900
	A376/TP316	51400	91050
	A376/TP316	42050	82500
	A376/TP316	41150	80900
	A376/TP316	49100	81200
	A376/TP316	40100	83000
	A376/TP316	40100	83000
	A376/TP316	40100	83000
	A376/TP316	41100	98400
	A376/TP316	39300	84200
	A376/TP316	41150	80900
	A376/TP316	45150	86600
	A376/TP316	41050	79600
	A376/TP316	41150	80900
	A376/TP316	41050	79600
	A376/TP316	41650	78550
	A376/TP316	41050	79600
Plant E	A376/TP316	38800	84500
Aux. lines	A376/TP316	45600	87900
	A376/TP316	41300	83200
	A376/TP316	41900	87400
Plant F	A376/TP316	41400	87100

Summary of Sample Certified Material Test Reports Review			
	Room temperature CMTRs properties		
Plant	Material	Yield Strength (psi)	Ultimate Strength (psi)
Aux. lines	A376/TP316	42400	86100
	A376/TP316	40900	86100
	A376/TP316	38900	79400
	A376/TP316	39300	82600
	A376/TP316	42500	83800
	A376/TP316	42200	86100
	A376/TP316	42200	86100
	A376/TP316	44900	84200
	A376/TP316	41200	81600
	A376/TP316	41700	85800
	A376/TP316	42900	84600
	A376/TP316	39700	83400
	A376/TP316	40200	85100
	A376/TP316	40200	83000
	A376/TP316	40900	82600
	A376/TP316	40200	84200
	A376/TP316	44500	86300
	A376/TP316	44600	84800
	A376/TP316	44200	85000
Plant G	A376/TP316	38200	82900
Aux. lines	A376/TP316	38200	82900
	A376/TP316	38200	82900
	A376/TP316	38200	82900
Plant H	A376/TP316	47100	88500
Aux. lines	A376/TP316	47100	88500
	A376/TP316	47100	88500
	A376/TP316	48600	88500
	A376/TP316	47100	88500
	A376/TP316	38400	79900
	A376/TP316	49300	83100
Plant I	A376/TP316	42700	88200
Aux. lines	A376/TP316	42700	88200
	A376/TP316	42700	88200
	A376/TP316	42700	88700
	A376/TP316	43300	85600
	A376/TP316	43300	85600

Summary of Sample Certified Material Test Reports Review			
	Room temperature CMTRs properties		
Plant	Material	Yield Strength (psi)	Ultimate Strength (psi)
	A376/TP316	44500	81400
	A376/TP316	44500	81400
	A376/TP316	44500	81400
	A376/TP316	43900	89800
	A376/TP316	44500	81400
	A376/TP316	44500	81400
	A376/TP316	44500	81400
	A376/TP316	44500	81400
	A376/TP316	43900	89800
	A376/TP316	44500	81400
	A376/TP316	38100	82600
	A376/TP316	43900	89800
	A376/TP316	44100	88600
	A376/TP316	43300	87800
	A376/TP316	43900	89800
	A376/TP316	43300	87800
	A376/TP316	44500	81400
	A376/TP316	44500	81400
	A376/TP316	40500	84600
	A376/TP316	43800	89800
	A376/TP316	44500	81400
	A376/TP316	44500	81400
	A376/TP316	44500	81400
	A376/TP316	44500	81400
	A376/TP316	44500	81400
Total 169 Heats	Average	45228.70	84704.73
Average Flow stress=	(45228.70+84704.73)/2=	64967 psi	
ASME Code Flow stress=	(30000+75000)/2=	52500 psi	
Ratio of flow stresses=	64967/52500=	1.237	

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 15.2.7-1 Item 7 Revision 1

Original RAI Number(s): None

Summary of Issue:

The revised DCD Section 15.6.5.4C (DSER OI 15.2.7-1P Page 14) states that the LTC phase analysis uses the NOTRUMP DEDVI case at 25 psia containment pressure reported in Section 15.6.5.4B as initial conditions, and the WGOTHIC analysis of this event as boundary conditions.

Please describe the model used to develop the containment backpressure and demonstrate that it represents a bounding and conservative estimate of containment pressure following a small break LOCA. Discuss any differences that may exist between this model and that used in the large break LOCA analyses. Please discuss how water spillage from a broken DVI line is mixed with the containment atmosphere and justify that the treatment is consistent with the Westinghouse ECCS evaluation model. Discuss the conservative treatment of non-safety related containment sprays and containment coolers in reducing containment pressure. Please also clarify if the 25 psia initial condition is consistent with the WGOTHIC analysis of the containment pressure as a function of time.

Westinghouse Response:

For AP600 and AP1000, two different WGOTHIC models were used to determine the containment backpressure that would exist following a LOCA event. Assumptions were used in these models to conservatively underpredict the pressure. These two models are discussed below.

Large Break LOCA Model for PCT Calculation

For this case, a simplified WGOTHIC model of the containment was developed to determine the containment pressure response during the blowdown portion of a double-ended cold leg break. This model consists of a single control volume that represents the containment, all the heat sinks inside containment, and a simplified thermal conductor representing the containment shell that is connected from the containment control volume to a control volume that represents the environment. The boundary conditions for this model are specified in Reference 1. The outside temperature of the shell is held at a constant temperature of 0F. The heat transfer coefficient inside containment consists of the Tagami correlation for the blowdown portion of the transient (first 29 seconds), and the Uchida condensation correlation for the time following blowdown. These heat transfer coefficients are applied on all the internal heat sinks as well as the inside of the containment shell. As specified in Reference 1, the Tagami correlation is multiplied by a factor of four, and the Uchida correlation is multiplied by a factor of 1.2.

Small Break LOCA Model to Determine Containment Backpressure

A second WGOTHIC model was used to determine the AP600 and AP1000 containment backpressure after a small break LOCA event. These results were used as the boundary conditions for small break LOCA NOTRUMP analyses and WCOBRA/TRAC long term cooling analyses. The model is the same as the evaluation model used to determine the peak containment pressure for the DCD with assumptions changed to minimize the pressure response. For AP600, this model was used to support the long term cooling analysis, but was not used for the small break LOCA backpressure. For AP1000, this model was used to support the long term cooling analysis as well as the double-ended DVI (DEDVI) break analysis.

This model is described in Reference 2 which was submitted to the NRC and reviewed as part of AP600 Design Certification. As specified in Reference 2, the following changes to the DCD WGOTHIC model were made for this analysis:

1. The DCD model is biased to maximize containment pressure. These assumptions were changed for the backpressure analysis to minimize containment pressure.

    - Heat transfer coefficient multipliers which are set to values less than unity for the peak pressure analysis are set to unity for the backpressure analysis
    - Heat sinks that are conservatively neglected for the peak pressure analysis are included for the backpressure analysis
    - Initial conditions inside containment that are biased to the highest operating pressure and temperature are set to the lowest operating pressure and temperature. Relative humidity is set to 100% to minimize the initial air inventory inside containment. Environmental boundary conditions are biased to maximize heat transfer from the passive containment cooling system and minimize the containment pressure.
    - The containment vent system is assumed to be open at the start of the event and closes on an SI signal. This allows an initial decrease in the air inventory which results in a lower containment pressure

2. Mass and energy release rates that are specific for the double-ended DVI break are included in the WGOTHIC model.

    - Water spilling from the broken DVI is assumed to enter the PXS compartment containing the break. This water does not interact with the containment atmosphere as it falls from the break.

Non-safety systems such as containment fan coolers and containment sprays are not considered for this analysis. The containment spray system is only used in the event of severe accidents. Its use requires the operator to align the pumps and water sources for operation (requires an operator to open manual valves out in the plant). The chilled water supply to the fan coolers is automatically isolated following an SI signal. The system can be restarted by the operator to assist in long-term recovery following a LOCA, and it is not considered in this shorter-term analysis.

Two sensitivity studies were done to determine the effect of these assumptions.

Cold Water Spill Sensitivity

The DEDVI break consists of two break flow paths; one from the vessel side, and one from the loop side. The vessel side break is a typical high-temperature, high-pressure two-phase blowdown. This two-phase flow is assumed to form droplets that are dispersed into the atmosphere of the break compartment. The recommended drop size is 100 microns. The loop side break flow consists of low-temperature (~80F), high-pressure single phase water. Normally, this water is spilled to the floor of the compartment and is not assumed to interact with the vapor-space region of the compartment. For this sensitivity study, the loop side break flow is assumed to be dispersed into the atmosphere of the break compartment.

Figure 1 shows the containment pressure response for the two cases. By allowing the cold water to interact with the steam and two-phase mixture in the compartment vapor space, the overall pressure is reduced by approximately 2 psi. The pressure remains above 25 psia between the time that the ADS4 flow becomes non-critical and the time of IRWST injection. The interaction between the steam and the water droplets in the compartment causes steam to condense resulting in less steam to pressurize the containment. In addition, the water droplets are heated so that the water accumulating on the compartment floor is saturated.

Heat Transfer Coefficient Sensitivity

The Tagami correlation is not considered appropriate for use in small break LOCA analysis. This correlation was developed to account for significant forced convection heat transfer that takes place during the blowdown period of a large break LOCA. This time period is about 30 seconds. For the DEDVI, the "blowdown" period extends to about 500 seconds during which an equivalent amount of energy is released from the RCS to the containment atmosphere as occurs for the large break LOCA. Since the forced convection in containment depends on a characteristic velocity, the velocities inside containment during the blowdown period can be compared for the two events by comparing the blowdown time. Thus, it is likely that the velocities would be at least a factor of ten lower for the DEDVI than for the DECL during the blowdown, and since the forced convection heat transfer coefficient is roughly proportional to the velocity, use of Tagami during a small break LOCA blowdown would significantly overpredicit the forced convection heat transfer. The Uchida correlation is recommended for these analyses.

As a sensitivity, the multiplier on the Uchida correlation was increased to 4.0 during the blowdown period (<500 seconds). Figure 2 shows the containment pressure response with and without this multiplier assuming mixing of the cold water spill as described above. These results show little sensitivity to the increased heat transfer coefficient.

The results of these sensitivity studies show that the containment backpressure boundary condition of 25 psia is valid for use in the DEDVI small break LOCA analysis.

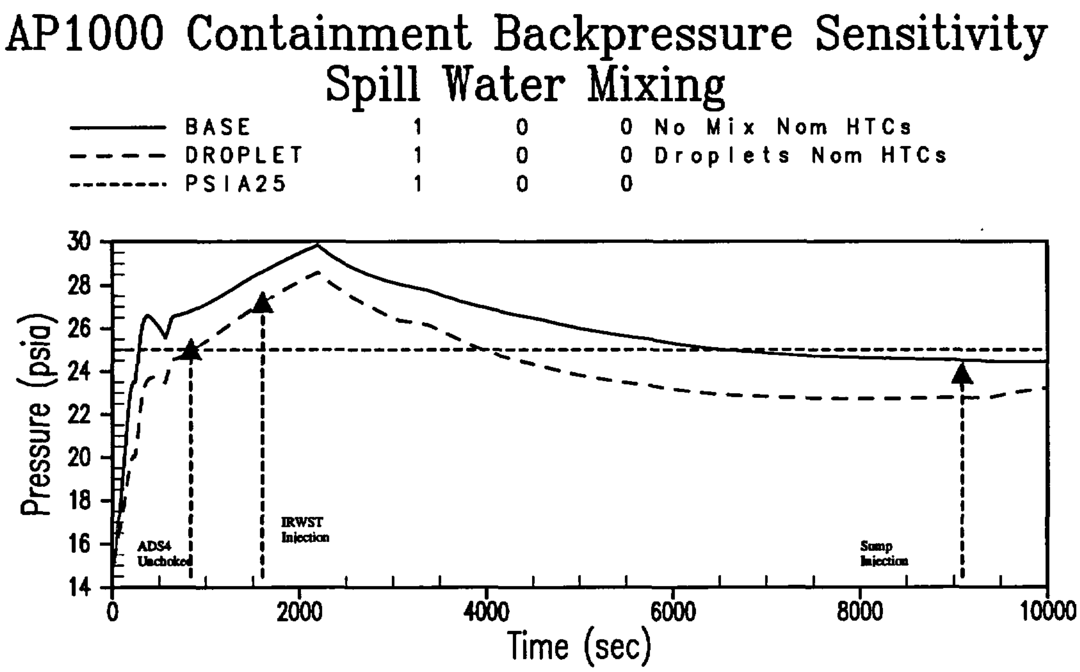


Figure 1: Cold Water Droplet Size Sensitivity

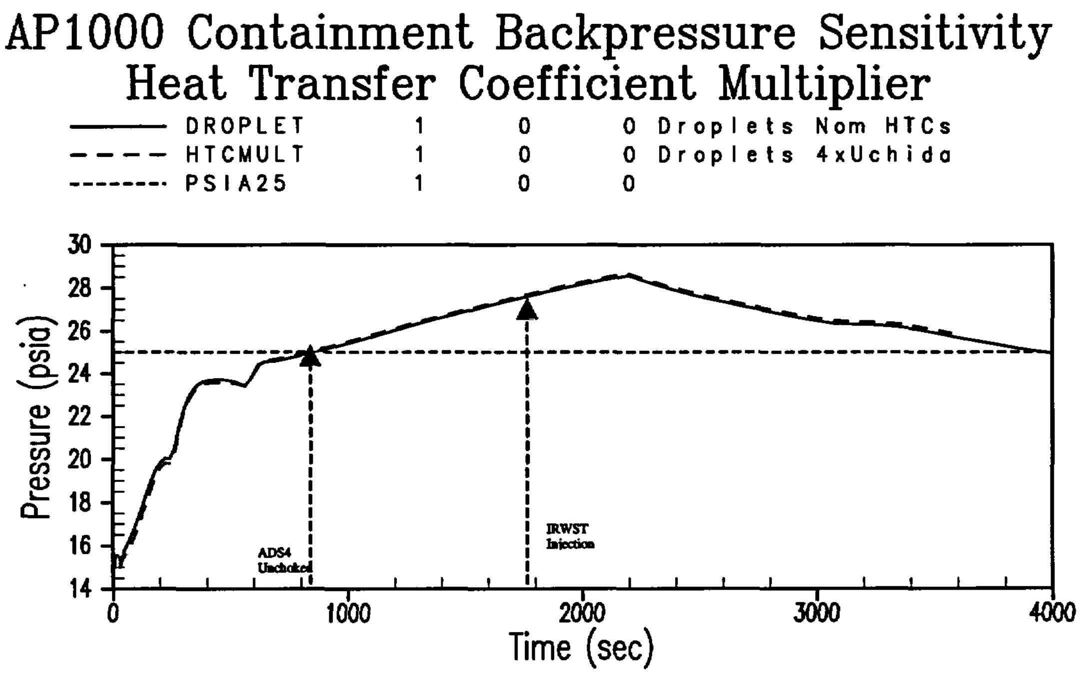


Figure 2: Heat Transfer Multiplier Sensitivity

References

1. WCAP-14171, Rev 2, WCOBRA/TRAC Applicability to AP600 Large Break LOCA March 1998.

2. WCAP-14601, Rev 2, AP600 Accident Analysis Evaluation Models, May 1998.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

AP1000 DESIGN CERTIFICATION REVIEW

Draft Safety Evaluation Report Open Item Response

DSER Open Item Number: 21.5-2 Item 28 Revision 1

Original RAI Number(s): None

Summary of Issue:

The APEX test matrix contained a subset of tests expected to produce the lowest vessel collapsed liquid levels. The selection of these tests was in part based on results of NOTRUMP simulations. Westinghouse indicated that similar liquid levels were predicted for inadvertent ADS 1-3, 2 inch hot leg break and the DEDVI break. The DEDVI break is considered to be limiting small break LOCA and assessment has focused on this case. Please demonstrate the adequacy of the NOTRUMP simulation of inadvertent ADS 1-3 to ensure that the limiting break has been identified.

Westinghouse Response:

The APEX-600 test matrix included a spectrum of break sizes and locations. The APEX-600 tests have been shown to scale adequately to AP1000 (WCAP 15613, "AP1000 PIRT and Scaling Assessment," February 2001). The NOTRUMP simulations of the APEX-600 tests, including the inadvertent ADS and DEDVI tests, are reported in WCAP-14807-P Revision 5, August 1998, "NOTRUMP Final Validation Report for AP600". Comparison of the NOTRUMP simulation core collapsed liquid level to test data for these two tests is reproduced in Figures 28-1 and 28-2. The APEX-600 DEDVI test exhibited a lower core collapsed liquid level than did the APEX-600 Inadvertent ADS test, although both tests exhibited adequate core cooling throughout. The NOTRUMP simulations for these two tests exhibit this trend of lower core collapsed liquid level for the DEDVI case as compared to the Inadvertent ADS case. The NOTRUMP simulations for APEX-1000 DEDVI tests are reported in WCAP-15644-P Revision 1, submitted by Westinghouse letter DCP/NRC1627 dated September 19, 2003, and show similar comparison to test data as for the APEX-600 DEDVI case. This provides confidence that the NOTRUMP analysis of the AP1000 small break LOCA spectrum, including the Inadvertent ADS case, are adequate.

Figure 28-3 shows the NOTRUMP calculated core exit vapor velocity for the AP1000 DEDVI event at two containment pressures (25 psia and 14.7 psia) and for the Inadvertent ADS 1-3 event at 14.7 psia containment pressure. The vapor velocity is higher for the DEDVI case at 14.7 psia than for the Inadvertent ADS 1-3 at 14.7 psia. Since the 14.7 psia containment pressure applies in the APEX-1000 test facility, this is another indication that the DEDVI tests performed in APEX-1000 are somewhat more limiting from the viewpoint of vapor velocity and its effects on entrainment and ADS4 venting.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

a,b,c

Figure 28-1

[ ] a,b,c

Figure 28-2

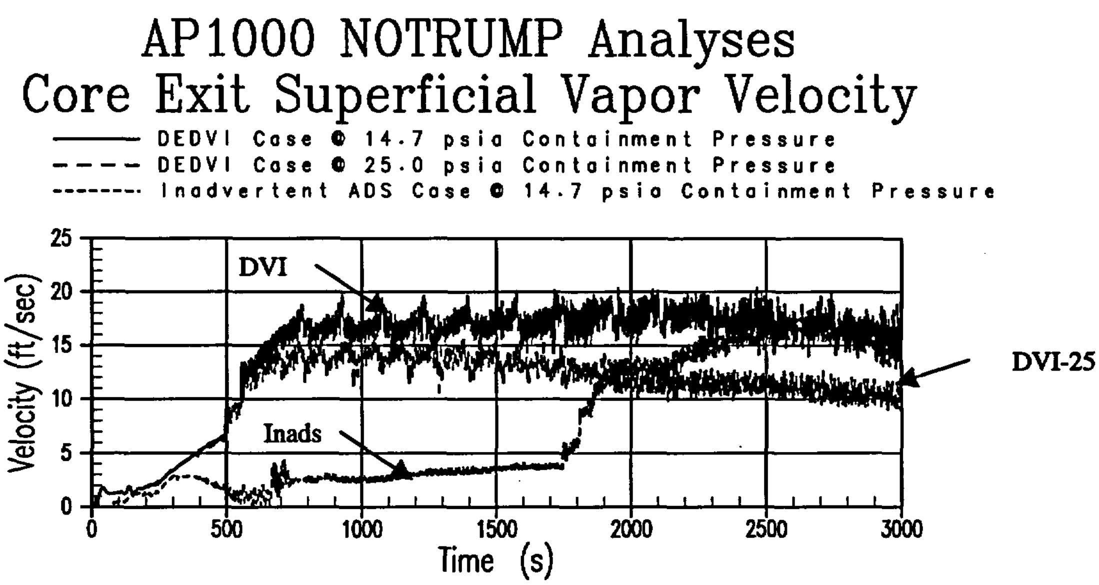

AP1000 NOTRUMP Analyses
Core Exit Superficial Vapor Velocity
DEDVI Case @ 14.7 psia Containment Pressure
DEDVI Case @ 25.0 psia Containment Pressure
Inadvertent ADS Case @ 14.7 psia Containment Pressure
DVI
Inads
DVI-25
Velocity (ft/sec)
Time (s)
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000

Figure 28-3