OSCAR SHIRANI, P.E.

Date of Birth: [redacted]
Service Date:
Citizenship:
Social Security No.:
Employe No.:

1C

Title:	Supplier Evaluation Specialist (Staff Engineer)
Work Location:	Downers Grove - ETW III, Suite 300
Extension No. :	Ext. 7934
Residence:	[redacted]
Telephone No.:	

1C

FORMAL EDUCATION:

M.S. in Civil Engineering, George Washington iiversity, Washington, D.C. [redacted]

B.S. in Civil Engineering, West Virginia Institute of Technology, Montgomery, WV [redacted]

1C

PROFESSIONAL AFFILIATIONS:

Member	American Institute of Steel Construction (AISC)
Member	American Society of Mechanical Engineers (ASME)
Member	American Society of Civil Engineers (ASCE)
Member	Member of Faculty Association, State of Illinois

NUCLEAR LICENSES HELD: None at this time

EMPLOYMENT HISTORY:

11/94 to Present:	Staff Engineer (Supplier Evaluation Specialist), Supplier Evaluation Services, Commonwealth Edison Company, Downers Grove
05/90 to 11/94:	Senior Engineer, Nuclear Engineering, Commonwealth Edison Company, Downers Grove
1980 to 1990:	Civil/Structural Engineer, Stone & Webster Engineering Corporation, Boston, MA (Served NUSCO, Duquesne Light & Power, VEPCo, Texas Utilities and Westinghouse prior to ComEd)
09/90 - 6/1995:	Part Time Instructor at Natural Sciences Department, College of DuPage, Illinois

621

EXPERIENCE SUMMARY:

Versatile structural engineering experience including management and business development. Excellent at developing marketing strategies, setting priorities and meeting objectives, providing innovative solutions and team building, training and leading engineers. Strong technical and quality background blended with project management. Personal strengths include integrity, high motivation, a passion for meeting challenges and strong creative ability.

SIGNIFICANT PROFESSIONAL & TECHNICAL DEVELOPMENT:

STRUCTURAL ENGINEERING

- Initiated and coordinated processes to reduce cost in analysis for the seismic and structural weak link qualification of the Motor Operated Valves (MOVs) at all six ComEd stations.
- Developed and promoted engineering in-house support capability for MOV issues, and created a technical support team dedicated to all ComEd stations.
- Managed to collect design material for in-house analysis eliminating the cost multiple contacts with vendors.
- Provided technical specialty support in analysis of vendor CFR Part 21 issues, eliminating downtime and replacement costs.
- Responded to numerous NRC questions through Nuclear Licensing Department on operability issues, and provided justifications for continued operation.
- Performed seismic analyses for structural frames, concrete beams, slabs, walls, and embedded and surface mounted plates.
- Designed retaining walls to resist earth landslide and hydrostatic loads resulting from Possible Maximum Flood (PMF).
- Designed and analyzed the turbine building operating floor trusses.
- Qualified equipment anchorages, and designed reinforced concrete pier and pad foundations.
- Performed concrete inspection of Cooling Towers & River Screen House.
- Utilized codes such as AISC, AWS D1.1, ASTM, ASME, ACI, ANSI, UBC and other Industry Standards.

CONSTRUCTION ENGINEERING:

- Directed foreman and construction engineers in the interpretation of specifications and procedures to resolve field problems, eliminating unnecessary design changes at five nuclear power plants other than ComEd.
- Initiated and resolved design changes, and justified ongoing construction activities including final inspection.
- Recommended the most cost effective approach for construction nonconformances and deficiencies.

QUALITY ASSURANCE LEAD AUDITOR:

Specialist in Quality Assurance programs of Suppliers, Manufacturers, and Architectural Engineering organizations.

TECHNICAL WRITING/TRAINING:

- Prepared the Structural Design Criteria, Revision 0, for Dresden and Quad Cities ComEd nuclear stations.
- Developed generic guidelines in the areas of Structural Support, Structural Rigging Analysis, Seismic Scaffolding and MOV Seismic Qualification.
- Conducted 19 technical training sessions in 1993 alone, at all ComEd nuclear stations in Seismic Scaffolding, Structural Supports Rigging Criteria and MOVs.
- Trained and mentored over 300 engineers and other site personnel to develop in-house technical capability.
- Developed new design criteria for Embedment Plates, Anchorage and Equipment at Millstone III Nuclear Power Plant.
- Issued an industry technical paper on elastic-plastic analysis application for highly stressed valve components for resolving operability issues.
- Fracture Mechanics principals and applications by Structural Integrity & Associates
- The Bolted Joints by ASME
- Various welding design and applications courses by AWS
- Votes Training for Valve Operations
- Structural steel design for nuclear power plants by S&L

- Structural seismic design by S&L
- Probabilistic structural analysis by S&L
- Root Cause Analysis for Power Plants by Dr. Chung Chu
- Nuclear Utilities Procurement issues Committee Audit Training
- BWR and PWR Generic Systems Training
- Word Perfect for Windows training
- Marketing and Sales Concept by Resource Department & Training Institute
- Seismic Qualification Utilities Group (SQUG) walkdown training for A-46 Nuclear Plants
- The Seven Habits of Highly Effective People
- IEEE Add-On Training (extension of SQUG) by Dr. Kennedy
- Supervisory Interviewing Skills
- Codes and Standard Training
- Auditor/Technical Specialist Training per ASME/ANSI NQA-1, NQA-2, N45.2 & 10CFR50 App. B
- Achieving Your Potentials
- Business Writing for Results, Fred Pryor Seminars
- Interpersonal Managing Skills
- Insights for Excellence
- Time Management

Oscar Shirani, P.E. Date

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SAVING.XLS TO: OSCAR SHIRANI
12/8/93

SSE Mechanical Group Cost Savings

Task	Description	Cost	Actual	Savings
Freeze Seals	Engineering Evaluation of freeze seals were performed by SSE 6@$5000	30,000	0	30000
Lead Shielding	Evaluations to hang lead shielding were performed by SSE and Rad Protection using modules prepared by S&L	200,000	50000	150000
Rigging	Evaluations done per TID by MM and SSE 70 @ $3,000	210,000	0	210,000
P.O. Transfer				
Tech Eval's	Perform Engineering Review for "Drafting Only" DCR's 4 @ $1000	4000	0	4000
Furmanite	Perform Evaluations of Furmanite Boxes where installation is not within scope of TID 4 @ $1500	6000	0	6000
Misc. Design Work	Qualification of nutserts for seismic mounting of AR440 Relays	5000	0	5000
Temp Alt's	Perform Engineering Evaluation to allow installation of VP chiller pressure gauge	1000	0	1000
	Repair of CV221 Sockolet, guidance provided to perform repair such that no RT required	7000	2000	5000
	Repair of Arc Strike on Rx head vent piping without RT by imposing a reduction in allowable stress	5500	1500	4000
	Design to replace DG bolts with studs and nuts	3000	0	3000
	Disposition DR 06-93-0162 overpressurization of DO piping by calculating stresses	1500	0	1500
	Allow grinding on FW 26A heater tubesheet	1000	0	1000
	Use previous evaluations to accept B2R04 pressurizer temperature transient	5000	0	5000
	Replace leaking Kerotest valve with a KSB by Tech Eval performing majority of evaluation in house	15000	2000	13000
	Determine Tmin for 2FW079A check valve	3000	0	3000
	Perform ECCS room cooler heat exchanger test result analysis 2@$5000	10000	0	10000
Total				451500

Conclusion: SAVINGS OF 210,000 (one unit one outage) X 12 units = $2,520,000 for each outage of all units if all have the same Amt of requests
BY CREATION OF BWR TID's & PWR TIDs.

WE HAVE CONTRIBUTED TOWARD ALMOST 50% OF BYRON SAVING BY CREATING TID-MS-18 "TEMPORARY RIGGING LOAD CRITERIA" O. Shirani

June 1, 1993

Subject: Promotion Recommendation
Oscar Shirani

Mr. D. Shamblin;

Mr. Shirani has worked in the Mechanical & Structural Design Group for three years. His performance evaluation (PPR) during that time has been excellent. He has contributed to the overall success of the group and has a solid work record. His major accomplishments include:

1. The first accomplishment is the cost containment of the MOV Seismic program. His innovative approach saved over $2 million in analysis cost. He has also reduced the number of emergency calculations necessitated by testing. This assisted in reducing the impact of the MOV program on the sites.

2. He has developed a rigging criteria to significantly reduce the number of rigging requests that are sent to the outside engineering contractors. He has conducted training for the site engineers as well as the contractor trade personnel. The training was thorough and well understood by the craft personnel.

3. He has trained and mentored young engineers. He has set an example of professionalism. His efforts were significant in establishing the Mechanical & Structural Design Group as the reliable source of expert engineering opinion. He has worked with the maintenance staff and Site Engineers to ensure the engineering products meet the customers expectations.

Mr. Shirani obtained his B.S. Degree in Civil Engineering from [redacted] at W.V.I.T (in 2 ½ years vs. 4 years). He completed his M.S. Degree in Civil Engineering from George Washington University in 1½ years in [redacted]

Oscar joined Stone & Webster Engineering Corp. in 1980 as an Engineer and promoted to Senior Engineer in 1984 and a Lead Engineer in 1986 and also supervised 15 Engineers for almost 2 years. He has been involved in Structural Analysis and Construction Engineering and Management with the utilities such as Virginia Electric & Power (North Anna & Surry Nuclear Plants), Northeast Utilities (Millstone III), Duquesne Light & Power (Beever Valley III), and Texas Utilities (Comanche Peak) as a SWEC Member. He joined CECo in May 1990 at Downers Grove as a Principal Engineer. He is also a part-time Math Instructor at the College of DuPage. He is a registered Professional Engineer since 1985.

We would add that before joining Commonwealth Edison Company, Mr. Shirani had ten years experience in the commercial nuclear industry at an A/E firm. This experience added to his excellent performance and justifies the request that he be promoted to Senior Engineer at the next promotional opportunity.

If you have any questions, please contact me.

Prepared by: B. Rybak

Approved by: K. Brennan

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Oscar Shirani

Category I: Academic and Training Accomplishments

Internal and External Specialized Training Related to Field.

IEEE Add On Training (Extension of SQUG) by Dr. Kennedy - 3 days class
Seismic Qualification Users Group (SQUG)- 5 days class
VOTES training (Valve Operations and Testing)- 5-days class
Linear and Non-Linear Fracture Mechanics principals and applications Course by Structural Integrity and Associates- 6 days class
Welding Design and applications by AWS- 3 days class
Root Cause Analysis course by FPI International, Dr. Chung Chiu- 3 days class
Structural Steel Design for nuclear power plants by S&L - 3 days class
Structural Seismic Design for nuclear power plants by S&L - 3 days class
Probabilistic Structural Analysis by S&L - 3 days class
Codes and Standards training - 1 day class

ASME Bolted joint course- 1 day class
Generic BWR Systems course- 10 days class
Generic PWR Systems course -10 days class

Total of 56 days (I per 5 class days)------------- 11 Candidate Rating Points.

Masters Degree in Civil Engineering --------- 10 Points

Registered Professional Engineer -------------- 5 Points

Total Points in Category I: 26>20>10

Note: Minimum Points Required for promotion to Technical Expert (Level 9) -10
Minimum Points Required for promotion to Principal Technical Expert (Level 10) - 20
I did not account for my college level teaching since I have taught Mathematics for five (5) years at COD and not the Engineering courses. I taught Engineering courses at the graduate school.

Category II: Industry Exposure

National Publications: Presented three (3) technical papers at MUG meeting (with the NRC presence from all regions), ASME PVP conference, and APC in the subjects of Motor operated Valves operability evaluations, elastic/plastic arguments to justify MOV yoke stresses exceeding the yield allowables, and short term seismic applications on structures.
Also presented the MOV valve operability evaluation methodology to Jim Gavoula, from NRC's region 3 in 1994 to justify the operability of over 60 MOV's at Dresden and Quad Cities which exceeded the design licenses allowables and justified the continued operation which saved our Company millions of dollars.

Note: In the NRC GL 89-10 program, utilities faced with the qualification of many safety related MOV's being under designed in term of seismic and thrust/torque values specially in the old vintage plants such as Dresden, Quad Cities, and Zion Stations. In the process of seismic qualification of some MOV's, the resultant loading components exceeded way above the yield strength of the limiting components such as Valve yokes which rendered those valves inoperable. My technical paper defended those valves in the order of 50% above yield strength of the yoke material and proved the valve operability by establishing deformation as an acceptance criteria by using the Elastic/Plastic analysis argument of the material. This methodology convinced the NRC that we don't have to shut down the plant everytime that we exceed the design allowables. Please note that there were no operability limits established by NRC nor the industry. That is the reason why this paper got a lot of utilities' attention, because it saves them millions of dollars by avoiding the plant shutdown and allows them to replace the overstressed valve yokes in the next planned refueling outage. *Please note that my last supervisor did not even publicly admired me for this task and I am almost positive that any other Company would have at least acknowledge this achievement for their own benefit if not for mine.*

Also reviewed a numerous ASME and MUG technical papers in the areas of pressure locking and thermal binding and finite element analysis of valve components.

Category III: Work experience

Specialty experience: 12 years in the areas of Mechanical/Structural analysis and Equipment qualification
3 years in the area of Motor Operated Valve seismic qualification and weak link analysis.

Performance Rating: All "Exceptional", except 1995 rating which was ME+ due to being in the SES for the first year and in the learning stage.

I have also prepared/reviewed many TID's (Technical Information Documents) in the areas of Structural Rigging analysis, Structural pipe support analysis, Seismic Structural Scaffolding, Motor Operated Valves Seismic and Weak Link analysis which are utilized by all our six (6) nuclear Stations on a daily routine basis.

Society Memberships:

Member of ASME, AISC, ASCE, ASQC, and ACI.
Pursuing the ASME committee membership in the area of Fabrication and Materials Engineering.

For the remaining accomplishments and credentials please refer to my updated Resume.

August 23, 1995
QVL 22-95-043

Mr.D. Felz
Supplier Evaluation Services
ComEd

Subject: Thank You!

Dear Don

Thank you for the assistance of Mr.O. Shirani during the weeks of July 24 through August 9, 1995. His contribution to Zion's Engineering and Technical Support Audit as an Auditor greatly contributed to the effort on assessing the Zion Site Engineering Department.

Mr.Shirani needed very little direction in assessing the Design Calculations and other design activities. Often, he worked without the assistance of other SQV personnel on the audit. This allowed the others to concentrate in their assigned areas.

He was very diligent and often stayed late to write up a daily report of what he observed and ideas for us to consider. Mr. Shirani understood Zion's perspective and offered other viewpoints for consideration. This was especially demonstrated in the area of the potential Part 21 issue. As a result of his independent assessment, we are examining and exploring his recommendations and findings to improve the Design Control Process at Zion station.

Mr. Shirani set a high standard for technical auditors for our future audits.

Sincerely,

Kenneth J. Hansing

Kenneth J . Hansing
SQV Director
Zion Nuclear Power Station

cc: T. Kovach - Nuclear Oversight
S. Jaffery - ComEd, Audit Team Leader
E. Netzel - SES, D.G.
O. Shirani - SES, D.G.
SQV Audit File - 22-95-05

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May 21, 1991

Subject: Outstanding Achievement Award
Proposed Team Award

Mr. L.O. DelGeorge,

As part of the overall corporate vision of improving the quality and cost of the engineering support for the stations, our Mechanical & Structural Design Group has issued a revised Structural Design Criteria for Dresden and Quad Cities Stations. This new design criteria enables ENC, Stations, and Architect/Engineer personnel to use a unified, updated, and complete design criteria for questions in the structural area.

The team members who performed this effort were Mr. S. Bakhtiari and Mr. O. Shirani. By performing this work in-house, a savings of approximately $370,000 was realized. Since the document is a Commonwealth Edison Document, there is no proprietary information contained in it. This allows the document to be transmitted to the various designers (A/E) who can use it for their designs.

The team gathered the structural information from the UFSAR/FSAR, specifications, and the existing design criterion. They eliminated extraneous information, corrected errors, and rewrote sections to eliminate the proprietary content. This effort was reviewed by the original designer and the review comments were incorporated. The document was then issued for use. The document has been used for design work at Dresden & Quad Cities and has been well received by the A/E's performing design work.

This effort deserves special attention because it represents an implementation of employee empowerment. They identified the problem, developed a solution, and requested resources. After receiving permission and resources, they developed the interfaces, schedule, and scope. The project was completed under budget and has quality which is excellent.

In conclusion, Mr. Bakhtiari and Mr. Shirani have shown the initiative and ingenuity to produce a valuable design criteria. This effort should be recognized and rewarded.

G. P. Wagner

ZMECH/1505
PD/klv

AN APPLICATION OF ELASTIC-PLASTIC ARGUMENTS TO JUSTIFY OPERABILITY OF HIGHLY STRESSED MOTOR OPERATED VALVE YOKES

Curtis J. Warchol, P.E., S.E.
VECTRA Technologies, Inc.
Naperville, Illinois

Oscar Shirani, P.E.
Commonwealth Edison Company
Downers Grove, Illinois

ABSTRACT

This paper presents an application of elastic-plastic analysis to justify operability of highly stressed Motor Operated Valve (MOV) yokes. The ductile properties of typical carbon steels enable valve yokes to exhibit structural capacities which are considerably higher than normally predicted by linear analysis. Common industry practice is to use an allowable stress no higher than 1.0 S_y (minimum specified yield strength) when evaluating valve extended components (i.e. yokes) for the applicable load combinations (typically seismic combined with thrust and torque). By examining the behavior of a typical yoke cross section which is stressed beyond first yield, it can be shown that the yoke displacement will remain on the order of elastic displacement until just before the yoke reaches its plastic moment capacity. Even at 95% of the plastic moment capacity, the overall displacement is only 60% greater than that at first yield and the permanent deformation of the yoke is only on the order of 20% of the displacement at first yield. Furthermore, to ensure valve operability, the calculated yoke deformations can be compared to the actual clearances in the valve to ensure that the stem will not bind and the valve will remain operable (i.e., functional). Based on these evaluations, an argument can be made to justify continued operation of the valve even if the [illegible] yoke stresses exceed the yield strength of the material. As a result, bending moments on the order of 150% of those allowed by the standard yield stress criteria (1.0 S_y) can be justified.

BACKGROUND

Occasionally a situation is encountered in which a calculated valve yoke overstress brings the operability (or functionality) of a valve into question. In this situation, if the calculated yoke stresses exceed the specified yield strength of the material the valve may have to be declared in-operable. This could cause the plant (if operating) to go into an operating mode referred to as an LCO (limiting conditions for operation) or possibly even force a shutdown until the necessary modifications can be performed. This paper presents an application of an alternative analysis method to justify continued operation of the plant until the next refueling outage when a stronger yoke can be installed.

The design stress allowables which have commonly been used for MOV seismic qualifications vary throughout the industry. Depending on the specific regulatory commitments for a particular station, stress allowables vary anywhere from 1.0 S (ASME allowable stress) to 1.0 S_y (minimum specified yield strength). These allowables have been established from either Code recommendations and/or engineering judgements. Since the yoke is an extended structure of the valve assembly and is not a pressure boundary component, there is typically no clear commitment to any specific Code of compliance. The use of these allowables is based on the judgement that limiting the stresses in valve yokes to the elastic range will ensure that the deformations will be small and non-permanent and the valve will remain functional. Experience backs this judgement up, since for later vintage plants valves are required to demonstrate functionality under static side load tests which typically stress the yoke to near the elastic limit.

When evaluating plant components for severe accident scenarios (i.e., Emergency and Faulted type events), it is acceptable to use "higher" allowables as permitted by the ASME code for pressure boundary components. These "higher" stress allowables can exceed the yield strength of the material. This is allowed because the inherent ductility of steel results in an ultimate capacity well beyond that which corresponds to the first yielding of the cross section's extreme fibers. Typically this approach has not been considered appropriate for dynamic equipment since excessive deformations could result in rendering the equipment non-functional. However, if it can be shown that the actual deformations are small enough such that equipment functionality is not compromised, then it should also be acceptable to exceed the material yield strength for dynamic equipment as well.

ACTUAL BEHAVIOR

A common misconception in the behavior of a steel section subjected to bending is that once the yield stress is exceeded, excessive permanent deformations will occur. On the contrary, the actual permanent deformation is relatively small until the plastic moment capacity is reached and a plastic hinge is formed. Figure 1 shows the stress-strain curve for a typical carbon steel (most yokes are made from carbon steels). As seen from the curve, once the yield strength is exceeded excessive strain takes place. The misconception originates by confusing this curve (from a tensile test) with the behavior of a steel cross section subjected to bending. In contrast, the cross section subjected to bending behaves quite differently. As the bending moment increases, it reaches the point of first yield. At this point only the extreme fibers of the cross section (the part of the cross section farthest from the neutral axis) begin to yield. As the moment is increased, the yielding progresses inward toward the neutral axis until the entire cross section is yielding. At this point, known as the plastic moment capacity, a plastic hinge is formed and excessive deformations take place. Between these two points (first yield and plastic moment capacity) resides the additional capacity which can be utilized to justify operability for cases where the first yield is exceeded.

An example of a typical yoke leg subjected to a lateral force will be used to demonstrate this behavior. For simplicity, the example will only consider a "beam mode" lateral load. In application, both directions of lateral load must be considered. A discussion on the effects of axial load and "frame mode" bending is provided in the next Section. (See "Other Considerations")

Figure 2 illustrates a typical rectangular yoke leg subjected to a lateral load (beam mode) due to a seismic acceleration of the actuator. In the elastic range, the displacement at the top of the yoke leg is given by the formula:

$$\delta_y = \frac{P_y \cdot L^3}{3 \cdot E \cdot I} \qquad (1)$$

The load(P_y) and the displacement(δ_y) represent the point when the extreme fibers of the yoke cross section first begin to yield. Beyond this point(in the in-elastic range), the displacement is given by the following formula (Reference 3) as a function of δ_y:

$$\delta = \left[\frac{P_y}{P}\right]^2 \left[5 - \left[3 + \frac{P}{P_y}\right] \cdot \sqrt{3 - 2 \cdot \frac{P}{P_y}}\right] \cdot \delta_y \qquad (2)$$

Table 1 summarizes the relative magnitude of the loads and displacements at various load points as calculated per Equations (1) and (2). Figure 3 is a graph of Table 1 showing applied load (i.e. actuator mass times seismic acceleration) versus displacement at the top of the yoke leg normalized to first yield. As seen from the graph, the yoke behaves almost elastically until the plastic moment capacity is approached. The slope of the line(or the yoke stiffness) is constant in the elastic range. As the load is increased and the member begins to yield, the slope of the line gradually decreases until it finally becomes horizontal at the plastic moment capacity. At this point excessive permanent deformations will take place since a slight increase in load will result in a significant increase in permanent deformation.

Point A on this curve represents the applied load and displacement corresponding to a 1.5 S allowable stress criteria as recommended by ASME Code Case N-62. Point B represents the same parameters except using a 1.0 S_y criteria. Points C, D and E represent these parameters at 1.2 S_y (80% P_p), 1.425 S_y (95% P_p) and 1.5 S_y (100% P_p) respectively(P_p is the load associated with the plastic moment capacity). Points F, G and H represent the permanent (i.e. plastic) deformation, corresponding to Points C, D and E respectively, once the yoke leg is unloaded. Figure 4 shows the stress diagrams corresponding to load points A-E. This figure illustrates the stress distribution in the cross section as the stress increases from the elastic range up to the plastic moment capacity.

As seen from the example, the actual displacements are on the same order as the elastic displacements. Even at 95% of the plastic moment capacity, the maximum displacement is only 160% of the displacement of first yield, and the permanent deformations are only a fraction (20%) of the displacements at first yield. From these results it can be concluded that if using an allowable stress of 1.0 S_y is acceptable based on experience and judgement that the deformations are small in the elastic range, the same logic can be used to justify an allowable for load into the in-elastic range. Therefore, using a stress allowable of (.95)(1.5)S_y based on elastic calculations (i.e., pseudo elastically) may be an appropriate operability limit provided the yoke deformations can be justified.

ALLOWABLE DEFORMATIONS

The preceding discussions have focused on stress criteria for determining yoke leg acceptability. These stress criteria have been indirectly related to displacement criteria by using experience and engineering judgement to determine the deformations are small. Before coming to a conclusion that yoke stresses in the elastic-plastic range are acceptable an evaluation of the actual deformations should be performed. The primary concern is that the yoke will permanently deform causing a misalignment of the stem. Since a MOV is a precise piece of mechanical equipment fabricated to very tight tolerances, it is important to ensure that yoke deformations will not prohibit the valve from performing its intended safety function by causing a binding of the stem. Permanent deformation is the primary concern. Most MOVs are only required to operate after a seismic event, therefore only the permanent deformations would exist at that time. However, even for valves which must operate during an event, permanent deformation is the main concern.

During an event, the yoke is moving from one side to another and is at its maximum displacement for only short periods of time. The valve will likely be able to stroke between oscillations. If the stem does bind, it will only be for a fraction of a second when the yoke reaches its maximum displacement and then it will release as the yoke springs back to the other side. The ability of a valve to stroke under these conditions is contingent on many factors, including the geometry involved, the stroke speed, the motor trip circuitry, etc. and should be investigated on a case-by-case basis.

The critical area of concern is a binding of the stem within the packing chamber. Using elastic-plastic analysis, the permanent deformation of the yoke leg can be calculated and compared to an allowable displacement. The valve vendor may have determined a displacement limit which ensures functionality either through testing or analysis. Alternatively, an allowable displacement can be calculated by examining the clearances (including the fabrication and installation tolerances) between the stem and the packing chamber to determine the maximum rotation due to actuator displacement allowed for the stem. Figure 5 depicts a typical MOV detailing the clearances in the packing chamber area. Using these dimensions an allowable displacement can be calculated. Additional areas for concern include a binding in the disc guide area and a binding between the stem and stem nut (frame bending mode only).

OTHER CONSIDERATIONS

In the example, several parameters were chosen such that the problem would be easy to solve. This section is intended to examine other scenarios and to determine what impact, if any, they have on the conclusions of this approach.

The important factors which were not included in the example are: 1) what are the effects of thrust and torsion on the yoke; 2) what differences are there for lateral loads in the "frame" direction; and 3) what about non-rectangular yoke cross-sections. These three items will be examined in greater detail below.

To consider the effects of axial load combined with bending, the plastic moment capacity for a rectangular member subjected to an axial load (F) will be considered. Consider the plastic moment stress block for the rectangular section as shown in Figure 6. The equations of equilibrium can be expressed as

$$F = S_y \cdot w \cdot x - S_y \cdot w\,(d - x) \tag{3}$$

$$M_p = \frac{S_y \cdot w \cdot x^2}{2} - S_y \cdot w\,(d-x)\,\left(x + \frac{(d-x)}{2}\right) - \frac{F \cdot d}{2} \tag{4}$$

Solving these two equations by substituting for x and simplifying, the plastic moment (M_p) can be written as

$$M_p = \frac{S_y^2 \cdot w^2 \cdot d^2 - F^2}{4 \cdot S_y \cdot w} \tag{5}$$

The moment which would be allowed by using a pseudo elastic analysis with a stress allowable of 1.5 S_y can be calculated by setting the elastic stress (P/A + M/S) equal to 1.5 S_y or

$$1.5 \cdot S_y = \frac{F}{w \cdot d} + \frac{M_p}{1/6 \cdot w \cdot d^2} \tag{6}$$

$$M_p = \left(1.5 \cdot S_y - \frac{F}{w \cdot d}\right) \cdot \left(\frac{w \cdot d^2}{6}\right) \tag{7}$$

Setting Eq. (5) equal to Eq. (7) and solving for F

$$F = \frac{S_y \cdot w \cdot d}{1.5} \tag{8}$$

Or in other words, using the pseudo elastic method will yield a conservative result as long as the axial stress is less than 2/3 the yield stress

$$\frac{F}{w \cdot d} < 2/3 \cdot S_y \tag{9}$$

Since experience shows that the stresses in valve yokes due to thrust alone are well below this level, using the pseudo elastic approach will yield a conservative result.

Actuator torsion on the yoke is primarily transferred into a shear couple which produces "beam mode" bending on the yoke legs. This load has the potential to cause bi-axial bending on the yoke legs. Bi-axial bending in the inelastic region is a complex phenomena. Because of the complexity, the approach recommended to evaluate this situation, per Reference 4, is to conservatively apply a straight line interaction equation as shown below.

$$\frac{M_x}{M_{px}} + \frac{M_y}{M_{py}} \le 1.0 \tag{10}$$

For a rectangular section, M_{px} and M_{py} can be written as

$$M_{px} = 1.5 \cdot S_y \cdot 1/6 \cdot w \cdot d^2 \tag{11}$$

$$M_{py} = 1.5 \cdot S_y \cdot 1/6 \cdot d \cdot w^2 \tag{12}$$

By substitution, Equation (10) becomes

$$\frac{M_x}{1/6 \cdot w \cdot d^2} + \frac{M_y}{1/6 \cdot d \cdot w^2} \le 1.5\ S_y \tag{13}$$

Which is identical to the pseudo elastic method. Therefore, using the pseudo elastic method is also acceptable (and conservative) for the bi-axial bending case. For bi-axial bending combined with axial load, the conclusions determined above remain valid.

Another area which must be examined is the affects of lateral loads in the "frame" direction. The example problem looked at "beam mode" bending; this section examines the differences associated with "frame mode" bending. Figure 7 shows the displaced shape for a lateral load in the frame direction. Due to the relative rigidity of the attached actuator, common practice in yoke analysis is to evaluate the yoke as a guided frame (note that each yoke leg bends independently). This forces the yoke into a double bending mode. Equation (1) is still applicable, however, it is applicable to only half the overall length. In other words, the length term in Equation (1) becomes L/2 and the total displacement is determined by taking twice the displacement at the yoke midpoint or

$$\delta_y = \frac{2 \cdot P \cdot (L/2)^3}{3EI} \qquad (14)$$

Equation (2) remains unchanged, therefore the normalized relationships shown in Table 1 and Figure 3 are also unchanged.

Another area to be examined is the differences associated with the various cross sections that are used in yoke designs. The most common yoke shapes used on motor operated valves include rectangular, tee-shaped, hollow circular segment, and rod shaped. The shape factor for a rectangle is 1.5 as shown earlier. For a typical tee-shaped yoke, the shape factor varies from approximately 1.8 to 1.9 in the strong direction, and 1.6 to 1.8 in the weak direction. For hollow circular segment yokes, the shape factor ranges from about 1.45 to 1.6 in the strong direction, and from about 1.9 to 2.2 in the weak direction (Ref. 6). The shape factor for a solid rod is 1.7. As can be seen above, the rectangle shape results in the smallest shape factor for all of the common yoke shapes with the exception of the strong direction of the hollow circular segment which in some extreme instances can be about 3% less. For this type of yoke, the weak axis usually controls the design anyway. In conclusion, using a shape factor of 1.5 is adequate for a majority of MOVs, however, if a unique yoke shape is used (i.e., W-shape) the effect of a reduced shape factor must be considered.

Other areas of concern should also be pointed out before proceeding. This evaluation did not consider the potential for yoke leg buckling. In some circumstances with long slender yokes, a buckling of the yoke legs under compression may govern. This possibility should be investigated to ensure it will not control the design. Another area for concern is associated with the actual torque to thrust conversion which may be affected by allowing the yoke to go into the inelastic range. Permanent yoke deformations result in a stem misalignment which will introduce a "rate of loading" effect for the valve (see Ref. 7). When using this approach, the rate of loading effect due to stem misalignment must be considered.

OTHER CONSERVATISMS

Using an elastic-plastic analysis to evaluate MOV yoke legs may cause concern about reducing the existing safety margin. Because of this, it is worth noting other conservatisms that exist in an analysis of this nature. For instance, in the example, the yoke material was assumed to be an elastic-perfectly plastic material with a yield strength of 36.0 ksi. In reality the actual yield strength of this material would likely be in the range of 10% to 20% higher (note that for any specific yoke, the actual yield strength could be equal to the minimum). Furthermore, the elastic-perfectly plastic assumption is very conservative. Actually, as the extreme fibers of the cross section begin to yield a certain amount of strain hardening will take place (see Figure 1). As a result the actual plastic moment capacity will be significantly higher than calculated. Additionally, there are several other conservatisms which exist. For instance, the stem is normally not considered in the analysis. In reality, for closed valves, the stem helps support the actuator thereby reducing the loads on the yoke leg. For open valves, the stem will help support the actuator once all the gaps have closed. Also, the accelerations used to determine the yoke loads are usually based on conservative analysis techniques such as response spectra analysis (as opposed to time history analysis). In summary there is still a significant safety margin available in this type of evaluation even when using elastic-plastic analysis techniques.

CONCLUSIONS

In conclusion, the actual permanent deformation of a valve yoke subjected to bending stresses in excess of the material yield strength is much smaller than often thought. Drastic permanent deformation does not take place once the yield strength is exceeded. On the contrary, a yoke will continue to deflect at near the elastic rate until the plastic moment capacity is approached. Based on these facts, elastic-plastic analysis can be used to justify operability by comparing the calculated permanent deformation to the vendor supplied displacement limit. If the vendor does not provide a displacement limit, it can be manually calculated if the valve clearances are known.

Using this approach is not recommended for final design, rather it is offered as an alternative evaluation method which can be used to justify continued operation. Use of this method can result in significant cost savings without compromising plant safety. There are many factors which must be considered on a case-by-case basis. Is the valve normally open or normally closed? Is the valve required to operate during the event? What are the actual geometries associated with the valve? All these questions should be adequately addressed when performing an analysis of this nature to ensure valve operability.

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2. ASME Code Case N-62-4, "Internal and External Valve Items, Section III, Division I, Classes 1,2, and 3".
3. Gere, James M. and Timoshenko, Stephen P., 1984, "Mechanics of Materials", 2nd Edition, PWS Publishers, Boston, MA.
4. Salmon, Charles G. and Johnson, John E., "Steel Structures, Design and Behavior", 2nd Edition, Harper and Row, New York, NY.
5. Crane/Aloyco valve clearance information, 14" gate valve Model 47-1/2XR.
6. VECTRA Calculation XCE091.0203 - Addendum 2 "Calculation of Shape Factors for Arc Shaped Hollow Sections", Rev. 0.
7. Lord, Bruce and Cyhoski, Chet, "Stem Nut Sideloading and Load Sensitive Behavior", presented at the Motor Operated Valve User's Group (MUG) Conference, Detroit, MI, August 1994.

TABLE 1

NORMALIZED LOADS AND DISPLACEMENT
AT SELECTED LOAD POINTS

Load Point	P/P_y	P/P_p	δ (in.)	δ / δ_y	δ' / δ_y'
A	0.730	0.49	0.059	0.73	1.00
B	1.000	0.75	0.081	1.00	1.00
C	1.200	0.80	0.098	1.21	0.83
D	1.425	0.95	0.131	1.62	0.32
E	1.500	1.00	0.180	2.22	0.00
F	-	-	0.001	0.01	-
G	-	-	0.016	0.20	-
H	-	-	0.058	0.73	-

P = Applied lateral load
P_y = Lateral load corresponding to first yield
P_p = Lateral load corresponding to plastic moment
δ = Lateral displacement due to P
δ_y = Lateral displacement due to P_y
δ' = First derivative of δ (stiffness of yoke at load P)
δ'_y = First derivative of δ_y (stiffness of yoke at first yield)

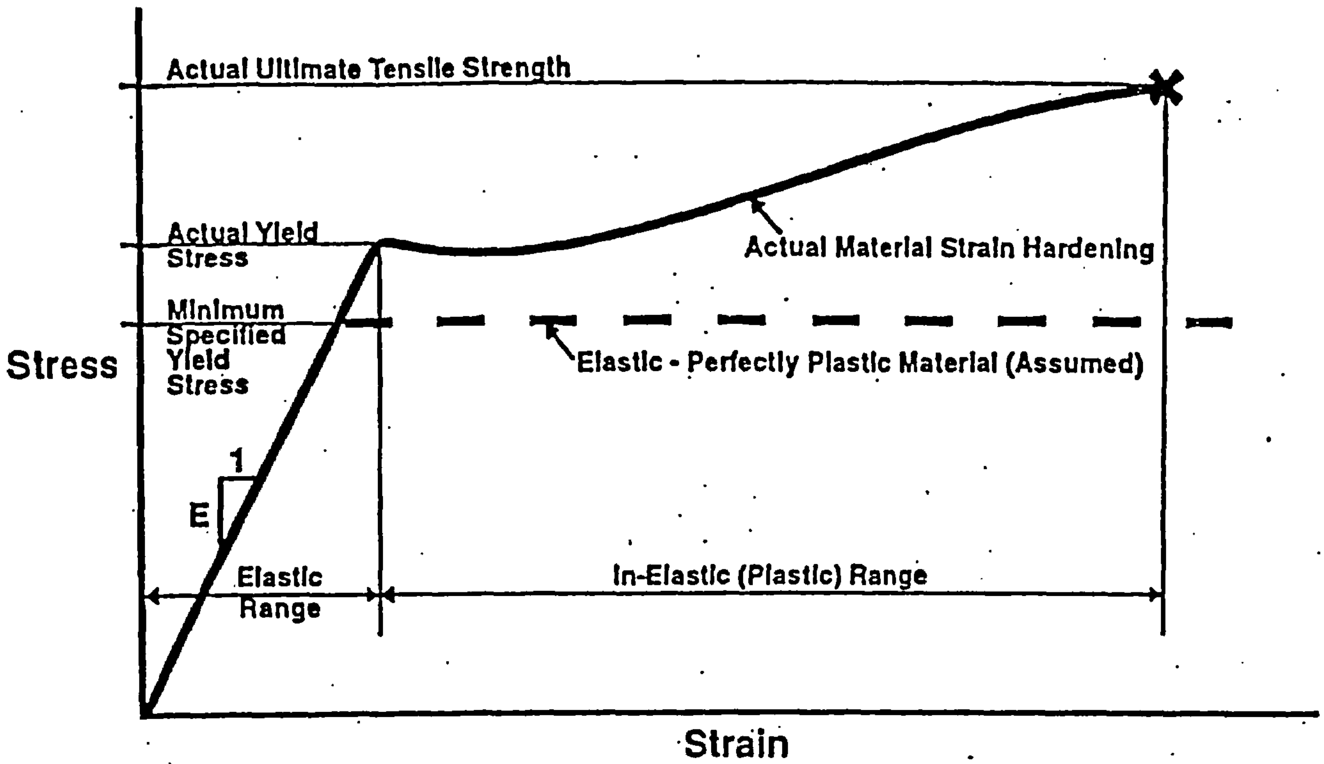


Figure 1

STRESS-STRAIN CURVE FOR TYPICAL CARBON STEEL

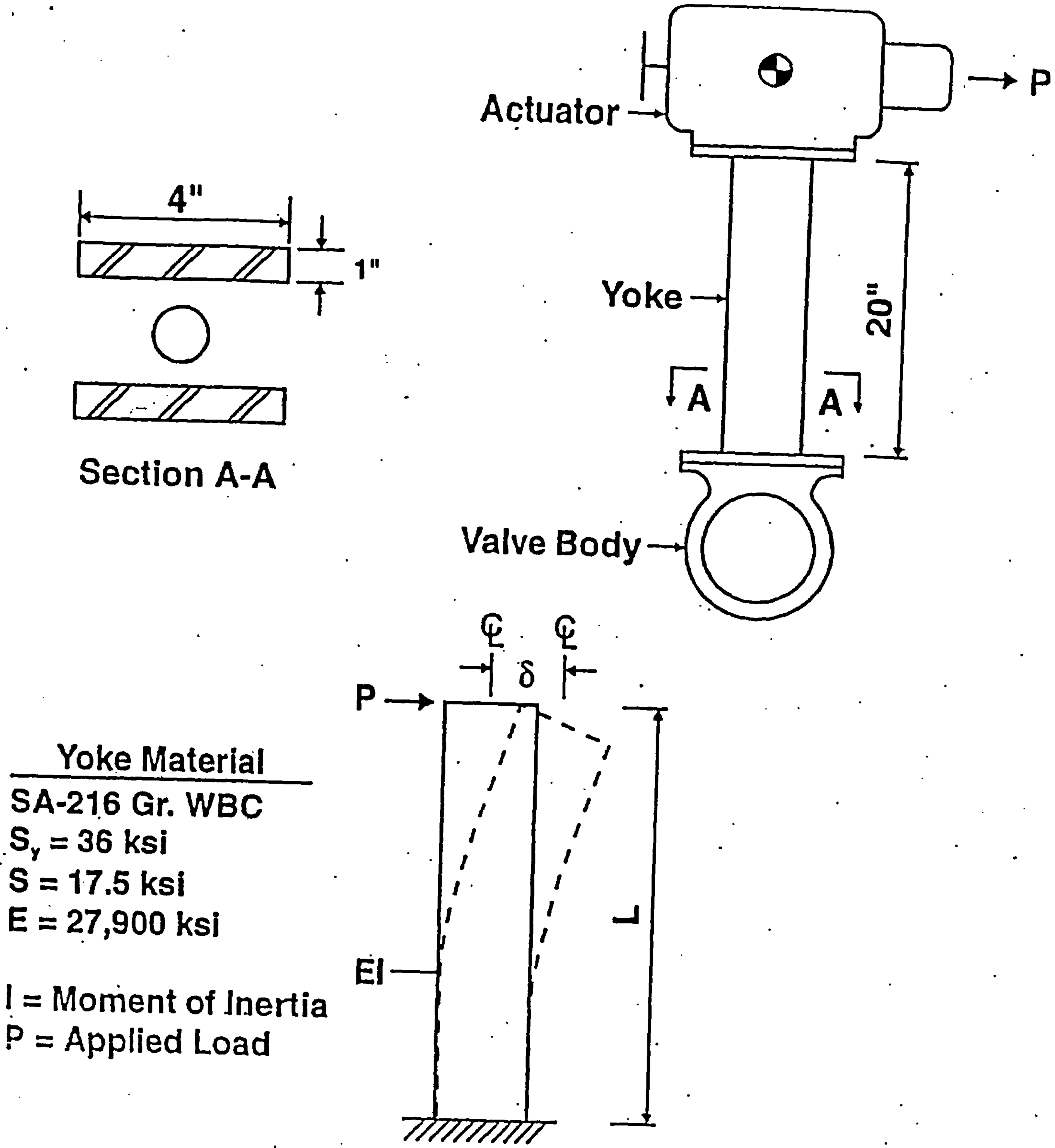


Figure 2
BEAM MODE BENDING EXAMPLE

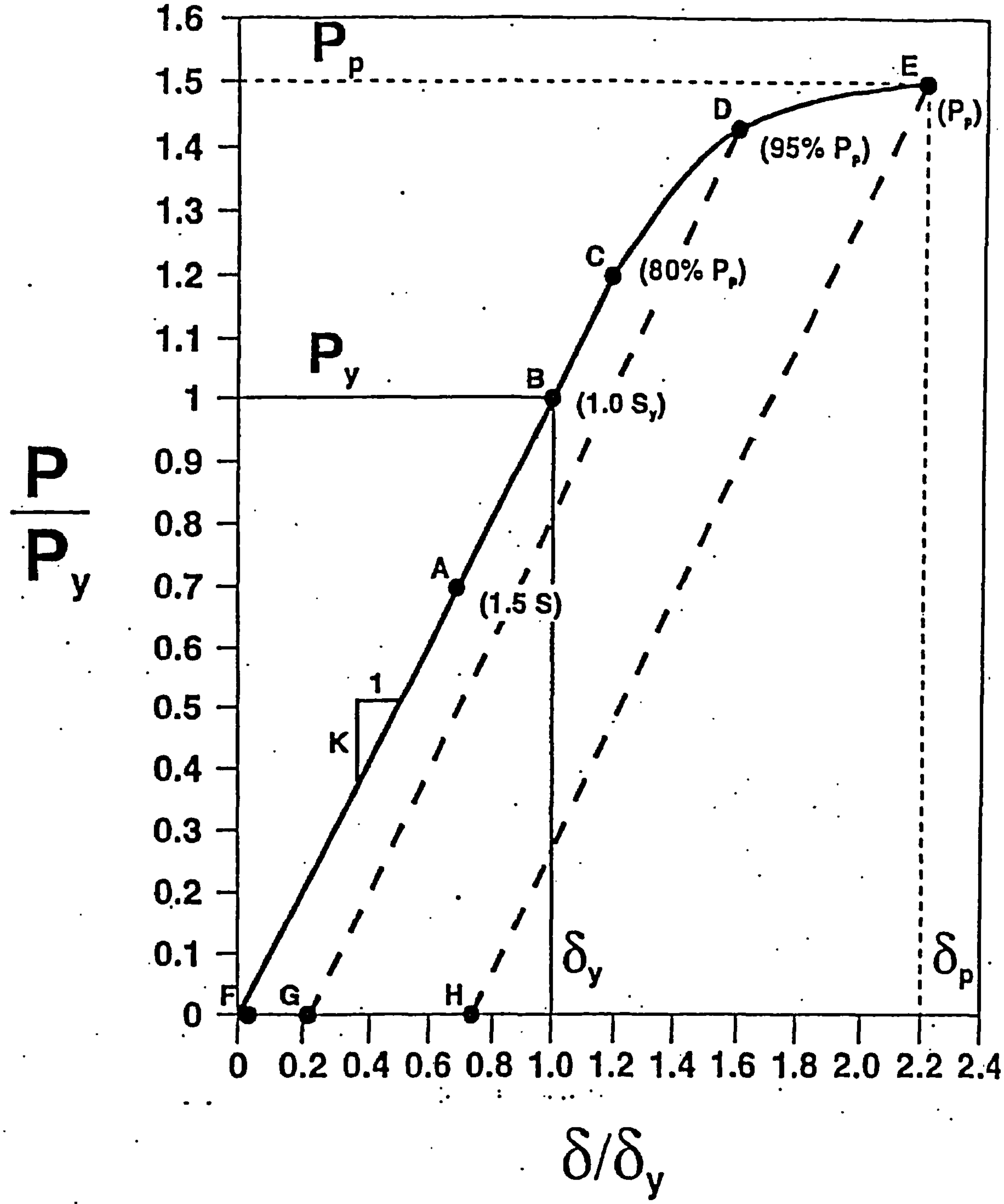
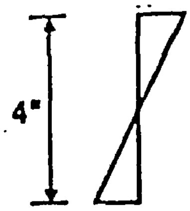
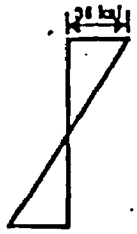


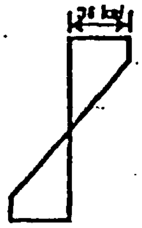
Figure 3
GRAPH OF LOAD VS. DISPLACEMENT
(normalized to first yield)



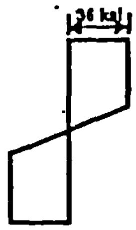
POINT A - Section is fully elastic.
Maximum stress is 1.5 S = 26.25 ksi



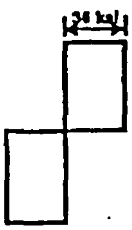
POINT B - Section reaches first yielding of extreme fibers.
Maximum stress is S_y = 36 ksi



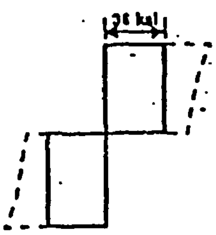
POINT C - Extreme fibers have yielded.
Section is in the elastic/plastic range.



POINT D - Further yielding has taken place.
Center section is still in elastic range.



POINT E - Section is fully plastic. Plastic Moment Capacity is reached a plastic hinge forms.



POINT E - Dotted lines show actual material properties including the effects of strain hardening.

Figure 4
STRESS DIAGRAMS CORRESPONDING TO SELECTED DATA POINTS

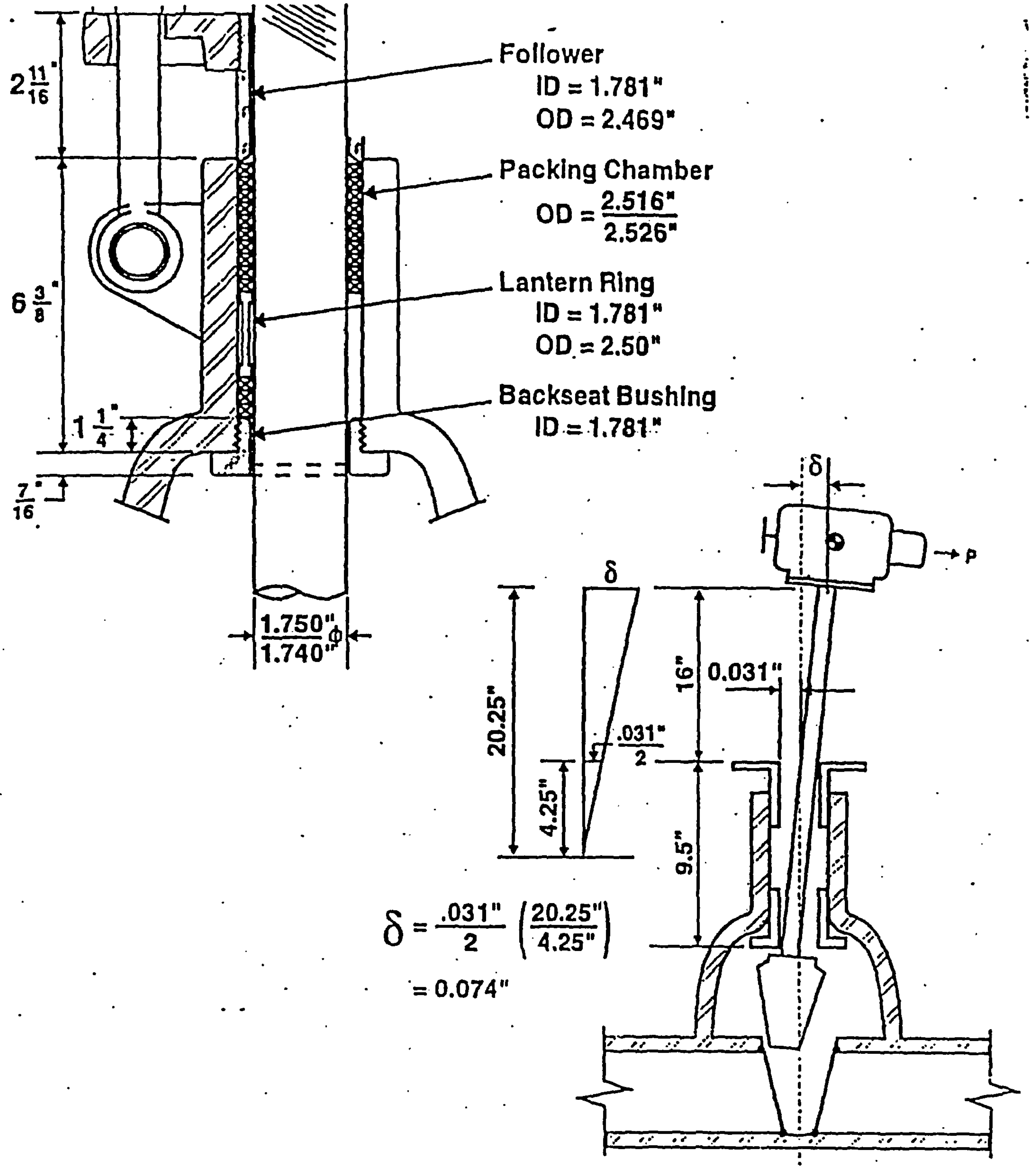
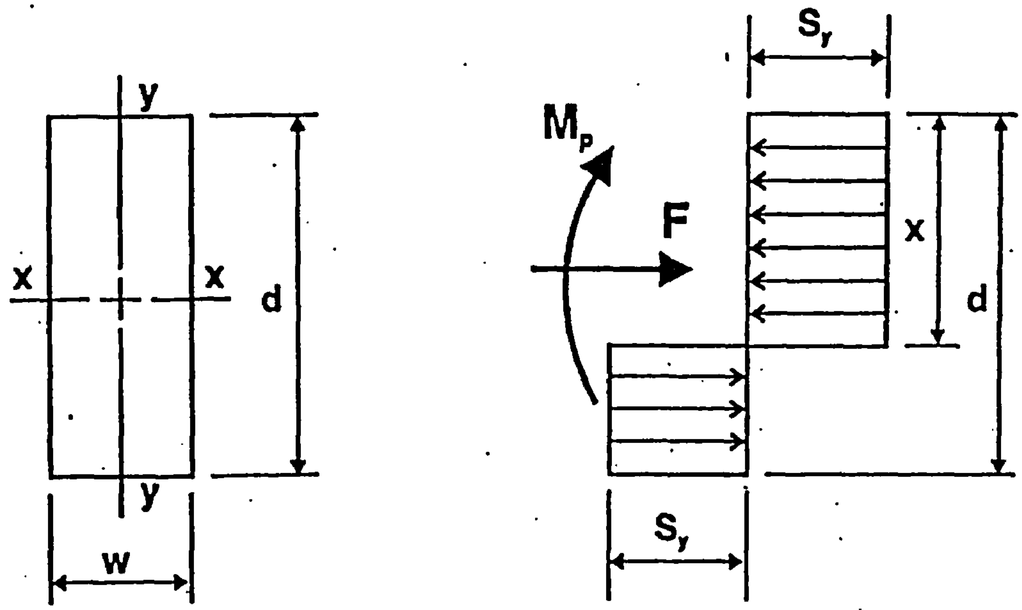


Figure 5
ALLOWABLE DEFORMATIONS
(Beam Mode Bending)



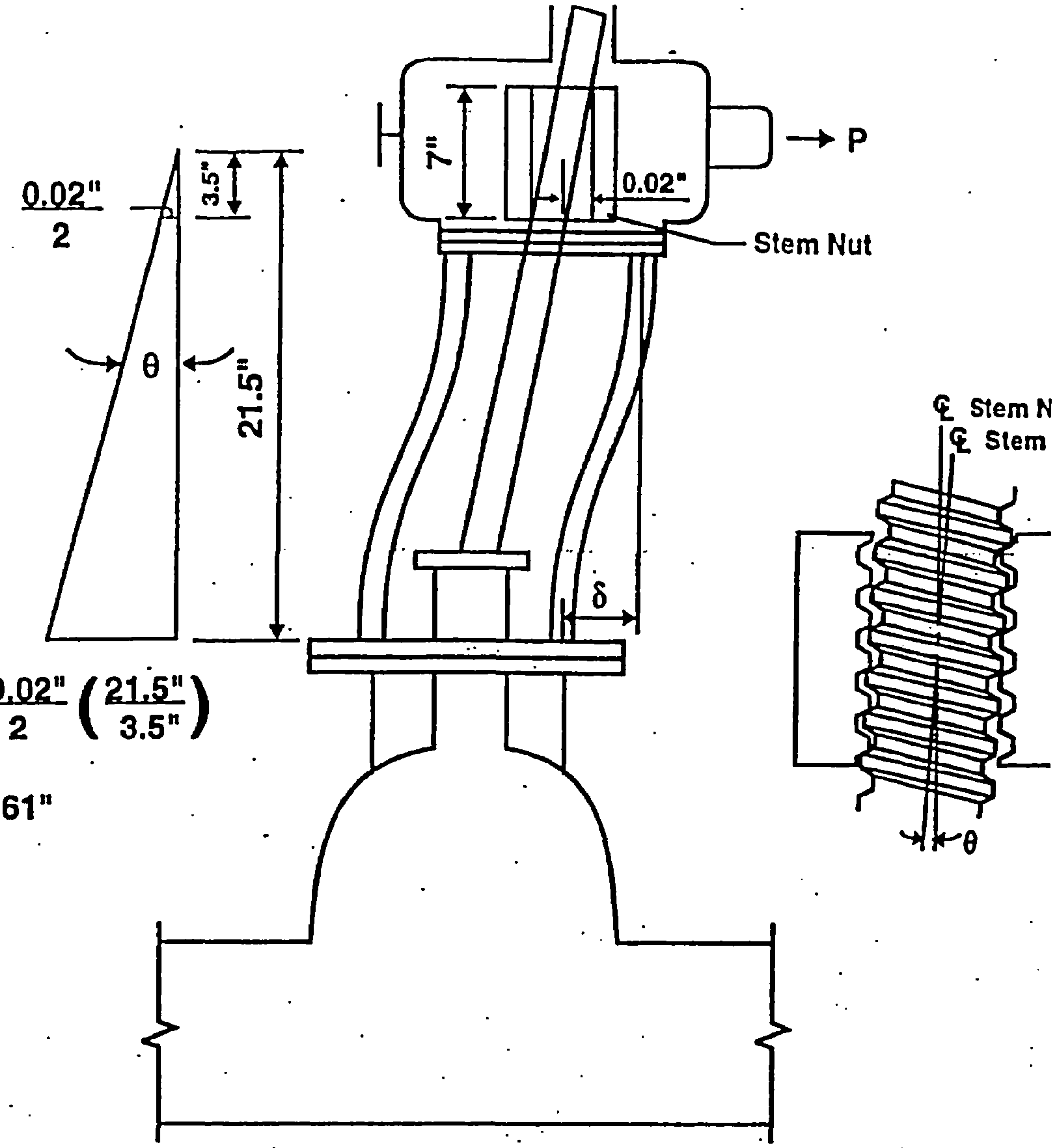
Yoke Cross Section

Stress Block

$$\Sigma F = S_y \bullet w \bullet x - S_y \bullet w \bullet (d - x) - F = 0$$

$$\Sigma M = \frac{S_y \bullet w \bullet x^2}{2} - S_y \bullet w \bullet (d - x)\left(x + \frac{(d - x)}{2}\right) - \frac{F \bullet d}{2} - M_p = 0$$

Figure 6
COMBINED BENDING PLUS AXIAL LOAD



$$\delta = \frac{0.02''}{2}\left(\frac{21.5''}{3.5''}\right)$$

$$= 0.061''$$

NOTE THAT ALLOWABLE DEFORMATION DUE TO ROTATION IN THE PACKING CHAMBER MUST ALSO BE EVALUATED

Figure 7
ALLOWABLE DEFORMATIONS
(Frame Mode Bending)

PRESENTED TO: ANDREW LYNCH
COPY: H. Kaiser & Malman.
BY: Francisco BARRILAS

The Cost of Data and Analysis

Two stories that demonstrate savings achieved by refusing to continue dependency on A/E's and NSSS Suppliers for Data and Analysis that should be resident at ComEd NOD.

Source: Interview s with O. Shirani, NOD Engineer
June 1997

Temporary Rigging Criteria

Engineering purchased from S&L load bearing data on key walls at the six sites.
Technical Information Documents (TIDs) for BWR and PWR walls were developed that allowed our own engineering to analyze the loading of walls for temporary rigs during outages.

- At every plant outage, Engineering purchased load bearing evaluations from S&L. An average outage would require between 80 to 200 evaluations at a charge ranging from $3,000 to $7,000.
- A ComEd engineer convinced all six sites and DG to contribute $20,000 each toward the purchase of the data on our walls that would allow us to do our own analyses.
- Engineer developed TID-MS-03 (BWR Rigging Criteria) and TID-MS-18 (PWR Rigging Criteria) for ComEd engineering use. The Engineer trained 300 additional engineers in the new TIDs. The TIDs provide a step-by-step simple method to do the analysis for each rig.
- Some sites completely endorsed the TIDs and stopped using S&L. Others were more tentative. Overall the NOD used the TIDs for 90% of the rigs per outage.
- However, as more engineers from the 300 leave, there are instances were S&L is asked to interpret our own TIDs for work on site.

- Cost Per outage pre-TIDs:
  Low: 80 evals x $3,000 = $240,000
  High:200 evals x $7,000 = $1,400,000
- Annual Cost to NOD pre-TIDs:
  (7 Outages)
  Between $1,680,000 and $9,800,000
- One time charge for data to develop TIDs:
  $20,000 x 7 sites = $140,000
- 90% usage of TIDs saves each site between $216,000 and $1,260,000 in S&L analyses each outage.
- 90% usage of TIDs saves the NOD between $1,512,000 and $8,820,000 each year.

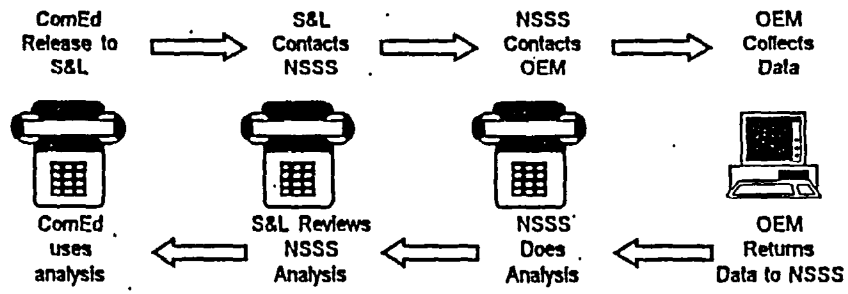
Motor Operated Valves Seismic and Weak Link Analyses

Every time an MOV needed to be upgraded or repaired, ComEd relied on S&L and other A/Es to do operability analyses against the original qualification. S&L would have to contact the NSSS supplier (Westinghouse or GE) to obtain data for the analysis. In many instances, the NSSS supplier would then contact the manufacturer to obtain the data. The final charge to ComEd ranged between $12,000 to $15,000 per evaluation.

- Very frequently, NSSS suppliers and A/Es were conjured in critical times to perform operability analyses on MOVs. The cost of each evaluation was never challenged as these analyses were mostly done to meet a certain time requirements to avoid bringing the unit down. The cost of these evaluations per valve ranged between $12,000 and $15,000.

- The following depicts how the charges added up for ComEd:

Final Charge from S&L incorporated charges they had to pay to obtain data from Westinghouse, and the charge that Westinghouse had to pay to obtain data from the OEM



- The NRC requested the qualification of all 1,600 MOVs for higher thrust and seismic factors to meet the new NRC GL-89-10 program. Our Engineer convinced our management to allow him to pursue purchasing the data directly from the Original Equipment Manufacturer (OEM). S&L strongly lobbied to stop this initiative. Nevertheless, our Engineering approved the initiative. Our Engineer contracted four independent engineers to do the evaluations and calculations. They obtained the data from the OEMs and moved the calculations to MATHCAD where it can be accessed and used by our own engineering force.

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Nuclear Operations HumanResources | 6th Floor, ETWIII
1400 Opus Place, Downers Grove, IL 60515

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