6.4 Stresses due to Rigid and Flexible Sleeves

Description:

In post-tensioned systems, sleeves are installed at the same time as reinforcing bars to be used later as conduits for the post-tensioning tendons. Note that they can alternately be called "sleeves", "conduits", or "sheaths". We are using the former in this analysis.

Different types of tendon sleeves are used in Nuclear Power Plant containment structures. Rigid sleeves are used in straight sections while flexible sleeves must be used to go around containment penetrations.

6.4a: Vibration of rigid sleeves
The hydro-blasting high-pressure water jets can induce stresses on the sleeves and concrete. Additionally, hydro-blasting can induce vibration of the exposed rigid sleeves leading to cracking in the adjacent concrete. In particular, thick-wall rigid sleeves are more prone to vibration than thin-walled flexible sleeves that would typically simply crush under the impact of the water pressure.

6.4b: No tensile transfer at the smooth concrete / rigid sleeve interface
Rigid sleeves have a smooth surface that can lead to very low concrete/sleeve bonding and virtually no tensile carrying capability across the bond.

Data to be collected and Analyzed:

1. Review the types of tendon sleeves that are allowed in the Design Basis Document (FM6.4 Exhibit 1) and in the Work Order (FM6.4 Exhibit 2);

2. Examine the sleeves used at CR3 (FM 6.4 Exhibit 3, FM6.4 Exhibit 4, and FM6.4 Exhibit 5);

3. Calculate vibration due to possible excitation of rigid sleeves by hydro-blasting water jets (FM 6.4 Exhibit 6);

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Draft 1

4. Examine the effect of no tensile transfer capability across the concrete/sleeve interface.

Verified Supporting Evidence:

a. The very smooth surface and lack of mechanical bonding at the sleeve / concrete interface leads to virtually no tensile transfer at the concrete / sleeve interface;

Verified Refuting Evidence:

a. Using different types of sleeves is allowed by the Design Basis Document (FM 6.4 Exhibit 1 and FM6.4 Exhibit 2);

b. Using smooth rigid sleeves is standard in other plants that have not experienced delaminations;

c. Vibration analysis shows that the hydro-blasting water jets on the exposed sleeves do not generate stresses large enough to create the delamination (FM 6.4 Exhibit 6);

Discussion:

Examination of the vertical tendon sleeves demonstrates a mixed use of flexible and rigid sleeves in the CR3 containment structure (FM 6.4 Exhibit 3 and FM 6.4 Exhibit 5). Photographs of the containment show rigid tendon sleeves for hoop and vertical tendons in the area of the SGR opening (FM 6.4 Exhibit 4).

Concrete pieces recovered after the demolition job show a very smooth interface between the concrete and the sleeve surface (FM 6.4 Exhibit 7);

Although the impulse generated by the high-pressure water on the concrete structure is not sufficient to generate the delamination through vibration, it is possible that the added energy was instrumental to propagating the crack beyond its original location. Because there is a layer of material where the radial tensile stresses are positive (albeit small on average) (see FM 1.2), once the crack is generated, it is "live" and can propagate until reaching a region of zero or compressive radial stress. This is the case near the buttresses and below the ring girder where the steel reinforcement can carry the tensile stresses.

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Draft 1

The mixed use of flexible and rigid smooth tendon sleeves is standard in the industry and in the case at most plants in the USA.

Because virtually no tensile load can be carried across the sleeve / concrete interface, the sleeves act like defects in the structure. In the various models, this is taken into account by having no cohesion or tensile stress carrying capacity between the sleeves and the concrete. The sleeves become potential initiators of cracks, especially as a very large traction is applied on one (but not the other) side of the sleeve.

This potential for crack nucleation is confirmed in the FEM analysis. It is captured at the discontinuity that represents each tendon location where traction is applied on the interior face only.

The analogy is that of tearing paper along pre-drilled aligned holes.

Conclusions:

6.4a: Hydro-blasting induced resonant vibration in the rigid sleeves did not cause the delamination. It may have contributed to the crack propagation.

6.4b: Poor bonding at the concrete / sleeve interface leads to considering the sleeves as 5.25" cracked regions in the structure. This is however an as-designed feature that was considered when the plant was first designed and constructed. It did contribute to the delamination by weakening the plane of the hoop tendons.

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Draft 1

Progress Energy	CRYSTAL RIVER UNIT 3 DESIGN BASIS DOCUMENT	Page 4 of 44	Rev. 6
SYSTEM NAME: CONTAINMENT - GENERAL		SYSTEM CODE: N/A	

PARAMETER	SOURCE	REASON
Reinforcing Steel		
Bars		
Original Construction ASTM A615 Grade 40 Repair of Delaminated Dome ASTM A615 Grade 60	The following G/C, Inc. specifications define the requirements for steel reinforcement for structural concrete: 1. SP-5646 2. SP-5648 The specifications are listed for reference only.	Intermediate grade billet steel reinforcement chosen because: a. Conforms to ACI 318, adherence to which is required by 10CFR50.55a. b. Economical, available material capable of satisfying design requirements.
Cadweld Reinforcing Steel Splices For splices of reinforcing bars larger than #11.	G/C, Inc. Struc. Specs. SP-5646 SP-5648 (for reference only).	Regulatory Guide 1.10, "Mechanical (Cadweld) Splices in Reinforcing Bars of Category I Concrete Structures." (formerly Safety Guide 1.10)
Prestressing Material		
Conduit (General) - 10 psig hydrostatic pressure capacity - galvanized steel - capable of supporting 200 pound man - sufficient size to accommodate a 163 wire tendon	The following G/C, Inc. specifications pertain to the following entries for conduit and are listed here for reference only: 1. RO-3040 2. SP-5844	All conduit must be capable of withstanding internal pressures due to injection of corrosion inhibiting grease. All conduit galvanized to prevent corrosion and further assure containment of grease. All conduit must be capable of withstanding unanticipated loads during installation and construction.
Rigid Conduit - Used in vertical and hoop tendons in cylindrical walls. - Round, mechanical welded tubing - ASTM A513-69 - 0.065" minimum wall thickness - 5 1/4" O.D. - 5" I.D.	See "Conduit (General)" for the Source of requirements cited on this page.	Most economical material available to withstand loads due to concrete placement and also due to the internal pressure exerted by the injection of corrosion inhibiting grease.

Progress Energy	CRYSTAL RIVER UNIT 3 DESIGN BASIS DOCUMENT	Page 5 of 44	Rev. 6
SYSTEM NAME: CONTAINMENT - GENERAL		**SYSTEM CODE:** N/A	

PARAMETER	SOURCE	REASON
Flexible Conduit - Used around penetrations in wall of containment. - Minimum 22 gauge - 5 1/4" O.D. - 5" I.D.		Flexible conduit specified in order to permit economical and efficient field fabrication and fitting.
Schedule 40 Conduit Used in foundation mat and containment dome. - ASTM A53-70, Type E or S Steel pipe Grade A for mat Grade B for dome	See "Conduit (General)" on Page 5 for the Source of requirements cited on this page.	Structural design material to ensure that dome conduit system is capable of supporting the dome liner under concrete placement loads. This conduit is, therefore, load carrying such that Grade B material (fy = 60 ksi) is specified. In the base mat the schedule 40 conduit (pipe) is the transition material between the trumpet in the base mat and the rigid conduit in the cylindrical wall. This pipe is not required to carry structural load, such that Grade A material (fy = 48 ksi) is considered adequate.
Tendon Wire ASTM A421-65 Type BA	Tendon wire is specified in G/C, Inc. Specification SP-5583 and is listed here for reference only.	Steel conforming to ASTM A421 is the standard material specified throughout the industry for use as a buttonheaded tendon wire. The steel used for this project is the Japanese equivalent of that material.
f_y = 240 ksi		Exceptionally high strength is required in order to develop the required level of prestress.
- Relaxation = 4%	See "Tendon Wire" on Page 6 for the Source of the requirement cited on this page.	Relaxation is a loss of stress when a wire is prestressed and maintained at a constant strain for an extended time. The degree to which this happens varies with the steel and is, therefore, specified by the steel supplier. That value must be known in order to evaluate the effective prestress over the life of the plant.

Document Header Sheet

RAN	90048- 6691
DOC NO	RO3Ø4Ø
3F3N #	

FLORIDA POWER CORPORATION
QUALITY ASSURANCE RECORD
TRANSMITTAL

6691

ATTENTION: RECORDS MANAGEMENT SECTION (NR2A)
CRYSTAL RIVER UNIT NO. 3

DOCUMENTS TRANSMITTED: Requirement Outline (RO)

Note* Documents are being transmitted for "HISTORICAL PURPOSES". These documents were transported to CR3 Site in the 1995 Engineering Migration from St. Pete to Crystal River

RO-3040, dated 6/12/70 (Includes Addendum A+B)
(28 pages)

The Quality Assurance Records listed above are hereby transmitted for inclusion in the Plant Quality File.

These records are complete and in compliance with the requirement of Florida Power Corporation's Quality Program.

Carole Butler — DATE 11/16/00
Responsible Supervisor/Designee

RECEIPT ACKNOWLEDGEMENT BY:

Kat Berg — DATE 11/09/00
Manager, Nuclear Information Resources/Designee

FUTURE RETENTION OF THESE RECORDS IS THE RESPONSIBILITY OF RECORDS MANAGEMENT.

FLORIDA POWER CORPORATION
POWER ENGINEERING & CONSTRUCTION DEPT.
CRYSTAL RIVER - UNIT 3

APPROVED BY:

Engineer _____ Date 11/29/71

Mgr. - Power Engr. ORIGINAL SIGNED BY W. A. SZELISTOWSKI Date 11/26/71

Nuclear Proj. Mgr. ORIGINAL SIGNED BY J. T. RODGERS Date 11/29/71

REQUIREMENT OUTLINE

PRESTRESSING SYSTEM TENDON CONDUIT

CRYSTAL RIVER - UNIT NO. 3
FLORIDA POWER CORPORATION

RO-3040 JUNE 12, 1970

FPC NO. 321-B4.1B

S. N. Dubbelt 11-17-71
APPROVED - DEPT. PROJECT ENGR. DATE

E. M. Hollerstein 11-17-71
ISSUED FOR CRYSTAL RIVER - UNIT 3 DATE

QUALITY PROGRAM
REVIEW and DOCUMENTATION
REQUIRED

REVISION	REVIEW & DOCUMENTATION REQUIRED		DESIGN ENGINEER
	YES	NO	
A	✓		
B		✓	SND

Gilbert Associates, Inc.
525 Lancaster Avenue
Reading, Pennsylvania

S.N.D.-M.L.L.
W.O. 4203-00
ADDENDUM A
May 13, 1971
ADDENDUM B
November 17, 1971

FLORIDA POWER CORPORATION
POWER ENGINEERING & CONSTRUCTION DEPT.
CRYSTAL RIVER - UNIT 3

APPROVED BY:

Engineer R W Buck Date 5/21/71

Mgr. - Power Engr. W O May Date 5/24/71

Nuclear Proj. Mgr. ORIGINAL SIGNED BY J. T. RODGERS Date 5/25/71

REQUIREMENT OUTLINE

PRESTRESSING SYSTEM TENDON CONDUIT

CRYSTAL RIVER - UNIT NO. 3
FLORIDA POWER CORPORATION

RO-3040 JUNE 12, 1970

FPC NO. 321-B4.1B

S N Dalton 5-13-71
APPROVED - DEPT. PROJECT ENGR. DATE

E R Hatteslen 5-13-71
ISSUED FOR CRYSTAL RIVER - UNIT 3 DATE

QUALITY PROGRAM
REVIEW and DOCUMENTATION
REQUIRED

REVISION	REVIEW & DOCUMENTATION REQUIRED		DESIGN ENGINEER
	YES	NO	
A	✓		ERH

Gilbert Associates, Inc.
525 Lancaster Avenue
Reading, Pennsylvania

S.N.D. - M.L.L.
W.O. 4203-00
ADDENDUM A
May 13, 1971

FLORIDA POWER CORPORATION
POWER ENGINEERING & CONSTRUCTION DEPT.
CRYSTAL RIVER - UNIT 3

APPROVED BY:

Engineer [signature] Date 7-1-70

Mgr. - Power Engr. [signature] Date 2-2-70

Nuclear Proj. Mgr. [signature] Date 12-6-70

REQUIREMENT OUTLINE

PRESTRESSING SYSTEM TENDON CONDUIT

CRYSTAL RIVER - UNIT NO. 3
FLORIDA POWER CORPORATION

RO-3040 JUNE 12, 1970

FPC NO. 321-B4.1B

QUALITY PROGRAM
REVIEW and DOCUMENTATION
REQUIRED

[signature] 6-12-70
APPROVED - DEPT. PROJECT ENGR. DATE

[signature] 6-12-70
ISSUED FOR CRYSTAL RIVER - UNIT 3 DATE

Gilbert Associates, Inc.
525 Lancaster Avenue
Reading, Pennsylvania

RECEIVED
NOV 29 1972
CRYSTAL RIVER
NUCLEAR PLANT

N.D.-M.L.L.
W.O. 4203-00

FLORIDA POWER CORPORATION

CRYSTAL RIVER UNIT 3

Table of Contents

TABLE OF CONTENTS (Cont'd)

1:00 INSTRUCTIONS TO BIDDERS

1:01 Invitation

Proposals are requested by the Florida Power Corporation for the equipment, materials, and related WORK, set forth in the attached Requirement Outline, which will be incorporated in the Crystal River Plant Unit 3, located approximately five miles northwest of Crystal River, Florida.

1:02 Submission of Proposals

1:02.1 Original and five copies of each proposal shall be submitted to:

Florida Power Corporation
P. O. Box 14042
St. Petersburg, Florida 33733

Attention: Mr. C. H. Thompson
Purchasing Agent

1:02.2 Proposals must be received by Florida Power Corporation or post marked prior to twelve noon AUG 5 1970.

1:02.3 Bidders shall furnish with their Proposals all drawings, catalog data, and other supplementary information necessary to describe thoroughly the materials and equipment covered by their Proposal.

1:02.4 Each Bidder shall submit with his Proposal the name of the manufacturer and the type or model of each principal item of the equipment or material he proposes to furnish. He shall also submit drawings and descriptive matter which will show general arrangement and dimensions, appearance, principle of operation and extent of factory assembly.

1:02.5 If the equipment cannot be shipped completely factory assembled, Bidders shall include with their Proposal the number, dimensions, and weight of each shipping unit and the amount of field work required to assemble completely the equipment.

1:02.6 The successful bidder may be required to furnish a service representative to work with Florida Power Corporation's personnel during the initial operation of the equipment. The services of this representative shall be outlined in the Proposal and the per diem charges stated separately.

1:02.7 One copy of provisional recommendations for spare parts shall be furnished with each Proposal.

1:02.8 Each Bidder shall include in his Proposal the cost of furnishing one complete set of all special tools, suitably packed and all in first class condition, which will be required for maintenance of the equipment covered by the Proposal.

1:02.9 The price stated in the Proposal shall include all taxes and licenses which might lawfully be assessed, on the date of the Proposal, against Florida Power Corporation or the Bidder, in connection with the proposed work. Exception:

1. If the price stated in the Proposal is for the furnishing of materials and/or equipment only and does not include field labor for erection and/or installation, do not include Florida State Sales Tax in your bid. Florida Power Corporation will pay such tax direct to the State of Florida.

2. If the price includes erection and/or installation labor to be performed at the job site, the Florida State Sales and Use Tax must be paid by the Bidder on the cost of the materials and supplies furnished. The Bidder awarded a Contract for this WORK shall be responsible for the payment of this tax to the State of Florida and should take this into account in his bid price.

1:02.10 The Bidders shall state in their Proposals that the materials and/or equipment will meet the Requirement Outline as set forth herein. Any exceptions to the Requirement Outline set forth herein shall be stated clearly in the Bidders' Proposals.

1:02.11 Bidders shall also state in their Proposals the complete terms of their warranty applicable to the materials and/or equipment they propose to furnish under this Requirement Outline, and the terms of extension of the warranty in the event of repair or replacement being required.

1:02.12 Bidders shall also state, in their Proposals, the extent of their guarantees for the performance of the equipment offered and for correction of items which fail to meet the warranty.

1:02.13 Royalties and fees for patents covering materials, articles, apparatus, devices or equipment used in the WORK shall be included in the Contract Price.

1:02.14 The Bidders shall not include, in their Proposals, the costs of insurance for equipment subsequent to receipt by the OWNER on the job site.

1:02.15 Bidders are advised that, due to the scope of this construction project, certain materials and equipment are required of necessity to be delivered considerably in advance of the actual commercial operation of the equipment. It is presently anticipated that actual commercial use, other than preliminary testing, of the material or equipment will not commence until September, 1972. Bidders are requested to take this into consideration in setting forth their warranty and guarantee terms.

1:02.16 Bidders shall set forth in their Proposals the terms of payment normal to their company or industry, including cash and/or trade discounts allowed, if any. Transportation charges shall be stated as to whether FOB destination, Shipping Point, or Shipping Point with full freight allowed to destination.

1:03 Evaluation of Proposals

1:03.1 The time of shipment of equipment and materials is a basic consideration of the Contract. The Proposals shall be based on the Bidders' ability to complete shipment in accordance with the schedule herein and it will be necessary that the Bidders satisfy Florida Power Corporation of their ability to make shipment within the stipulated time.

1:03.2 It shall be understood that the evaluation of Proposals received in accordance with these Instructions to Bidders and the attached Requirement Outline will be conducted solely by Florida Power Corporation.

1:04 Acceptance of Proposals

Florida Power Corporation reserves the right to accept or reject any or all Proposals.

1:05 Awards to Bidders and Payment

Florida Power Corporation will issue all purchase orders and make payment for the materials and/or equipment purchased.

1:06 Shipping Information

Bidders are advised that the shipments may be made to the plant site by the following carriers. All shipments shall be consigned to Florida Power Corporation, Crystal River Plant Unit No. 3:

Via Railroad:	Seaboard Coast Line (SCL) delivering carrier: Carload shipments only-destination station Red Level Junction Florida. L.C.L. Shipments-destination station Crystal River, Florida
Via Truck Lines:	Commercial Carriers-destination Red Level, Florida
Water Transportation:	A 15 foot deep barge channel has been dredged from the Gulf of Mexico to the plant site. Contact Florida Power Corporation for particulars if barge delivery is contemplated.
Parcel Post:	P. O. Box 276, Crystal River, Florida 32629.

2:00 GENERAL CONDITIONS

2:01 Scope

These General Conditions are applicable to equipment, materials and related WORK which will be incorporated in the new addition to Florida Power Corporation's Crystal River Plant.

2:02 Definitions

It shall be understood that the following terms as used in the specifications shall have the meaning herein given:

"OWNER" shall mean the FLORIDA POWER CORPORATION.

"ENGINEER" shall mean GILBERT ASSOCIATES, INC., Consulting Engineers.

"CONTRACTOR" shall mean the successful bidder for the WORK who will undertake the performance of the WORK required by the Contract.

"WORK" shall mean labor, services, materials and equipment as set forth in the CONTRACT DOCUMENTS.

"EQUAL" shall mean equal as approved by the OWNER or the ENGINEER.

"CONTRACT DOCUMENTS" shall mean all Drawings, Specifications and Addenda thereto as prepared and issued by the OWNER, the Invitation to Bid, the CONTRACTOR'S Proposal, and Manufacturer's Drawings as approved by the ENGINEER, all of which are part of the CONTRACTOR'S Contract with the OWNER. These CONTRACT DOCUMENTS are complementary, and what is called for by any one of them shall be as binding as if called for by all. Any conflicts in the CONTRACT DOCUMENTS shall be resolved by the OWNER.

2:03 Equipment and Materials to be Supplied by the Contractor

All equipment and materials furnished under Requirement Outlines shall be manufactured within the continental limits of the United States of America.

2:04 Codes and Standards

Unless specified otherwise herein, equipment and materials shall comply with all governing regulations and with the applicable standard specifications and codes of USAS, ASTM, ASME, IPCEA, NEMA, EEI, IEEE, UL and other such regular published and accepted standards. The regulation, specification or code applied in each case shall be the latest version of such regulation or standard adopted and published at the date of taking bids. Any conflict between standards shall be referred to the OWNER who will determine which standard shall govern.

2:05 Laws and Regulations

All equipment and WORK shall be in accordance with the laws of the State of Florida and the Rules of the Florida Industrial Commission.

2:06 Engineering and Drawings, Shop and Erection Drawings

2:06.1 Upon Award of a Contract, engineering data covering all equipment and fabricated materials to be furnished shall be submitted promptly by the CONTRACTOR for approval.

2:06.2 The CONTRACTOR shall submit 2 sepia copies and 2 prints of preliminary drawings and necessary data for approval, to the ENGINEER, at the address below:

Gilbert Associates, Inc.
Consulting Engineers
525 Lancaster Avenue
Reading, Pennsylvania 19603

Attention: Mr. E. R. Hottenstein

2:06.3 These drawings shall be sufficient and complete for system design purposes and for use in designing associated systems.

2:06.4 For final approval, the CONTRACTOR shall submit 2 sepia copies and 2 prints of drawings and necessary data for approval to the ENGINEER.

2:06.5 On each drawing submission (original, revisions and final) the CONTRACTOR shall send one copy of each drawing and data direct to:

Florida Power Corporation
P. O. Box 14042
St. Petersburg, Florida 33733

Attention: Mr. W. O. May
Manager - Power Engineering

2:06.6 These drawings shall be sufficient and complete for adequate erection, operation and maintenance of the equipment. The engineering data shall include drawings and descriptive information in sufficient detail to show the kind, size, arrangement and operation of component materials and devices; the external connections, anchorages and supports required; performance characteristics; and dimensions needed for installation and correlation with other materials and equipment. Data submitted shall include all required piping arrangement drawings, design calculations, pneumatic control system schematic diagrams, detailed drawings and data for structural systems, and complete power and control circuit logic diagrams, schematics and wiring diagrams.

2:06.7 No WORK shall be performed in connection with the fabrication or manufacture of materials and equipment, nor shall any accessory or appurtenance be purchased until the drawings and data therefore have been approved, except at the CONTRACTOR'S own risk and responsibility.

2:06.8 Exceptions to paragraph 2:06.7 shall be by agreement with the OWNER.

2:07 Instruction Manuals

2:07.1 The CONTRACTOR shall furnish eleven complete and final copies of instruction manuals not later than 60 days prior to shipment of the equipment. Ten copies shall be sent to:

Florida Power Corporation
P. O. Box 14042
St. Petersburg, Florida 33733

Attention: Mr. W. O. May
Manager - Power Engineering

One copy shall be sent to:

Gilbert Associates, Inc.
Consulting Engineers
525 Lancaster Avenue
Reading, Pennsylvania 19603

Attention: Mr. E. R. Hottenstein

2:07.2 The instruction manuals shall cover complete installation, operating and maintenance instructions, drawings and parts lists for each item of equipment furnished.

2:07.3 The instruction manuals shall be bound with covers suitable for rough usage. The front covers shall be stamped with lettering indicating the OWNER'S name, unit number, name of power plant, location of power plant, name of equipment, basic capacity rating of equipment and name of manufacturer.

2:08 Recommended Spare Parts

The list of recommended spare parts, with the price of each such item, and a schedule of required lubricants, as recommended by the manufacturer of each item of equipment, shall be included in the instruction manuals.

2:09 Design and Manufacturing Program

2:09.1 The manufacturer's design engineer shall be prepared to visit the office of the OWNER or the ENGINEER for design conference at such times as are required to expedite the handling of engineering matters.

2:09.2 The Contract program will be controlled by CPM diagrams and the CONTRACTOR shall provide all necessary information requested by the OWNER or the ENGINEER for compilation of these. In general, information required will include drawing schedules, purchasing schedules for major equipment items, and delivery dates.

2:10 Manufacturing Errors

Equipment and materials shall be complete in all respects within the limits herein outlined. All manufacturing errors or omissions required to be corrected in the field shall be performed by the CONTRACTOR, at his expense; or if done by the OWNER, the cost of same shall be borne by the CONTRACTOR.

2:11 Bill of Material

2:11.1 The CONTRACTOR shall prepare a Bill of Material covering all material and equipment furnished under this Requirement Outline. The Bill of Material shall be submitted in a preliminary form with the preliminary drawing submission and be finalized approximately two weeks before the scheduled arrival time of the first shipment. The Bill of Material shall be itemized in sufficient detail to permit an accurate determination of the completion of shipment of the material and equipment furnished under this Requirement Outline.

2:11.2 The mailing address for the finalized Bill of Material is:

Florida Power Corporation
Crystal River Plant Unit No. 3
P. O. Box 276
Crystal River, Florida 32629

Attention: Mr. H. L. Bennett
Construction Manager

2:11.3 All items of equipment delivered to site shall be marked adequately to allow identification from the Bill of Materials.

2:11.4 If the equipment is to be shipped in sections, with accessories or appurtenances detached, or otherwise not completely factory assembled, the extent of assembly shall be in accordance with the information submitted with the Proposal regarding the number, dimensions and weight of each section, accessory or appurtenance and the amount of field work required to assemble completely the equipment.

2:11.5 Suitable labels shall be affixed to all pre-assembled/pre-fabricated parts.

2:12 Manufacture and Inspection of Equipment

2:12.1 The CONTRACTOR shall advise the OWNER of all his major subcontractors before orders are placed and he shall not place orders with any subcontractor until approval of the OWNER has been obtained. The CONTRACTOR shall indicate where the equipment will be fabricated and the OWNER and/or its representative shall have the right to inspect all manufacturing facilities before approving the subcontractor.

2:12.2 The OWNER and/or its representative reserves the right to inspect fully all phases of manufacture of the equipment included in the Contract. Any item found to be unsatisfactory shall be replaced or repaired at no cost to the OWNER. Any inspection by the OWNER and/or its representative shall not relieve the CONTRACTOR of his responsibility for conforming to the stated conditions and shall not be considered a waiver of warranty, or other rights. No repairs or changes in excess of original Requirement Outline or applicable codes, if requested by the inspector, shall be made without the approval of the OWNER.

2:12.3 All shop tests required for certification and proof that the equipment conforms to all applicable codes and standards shall be made at the expense of the CONTRACTOR. Any additional tests required by the OWNER and/or its representative shall be at OWNER'S expense with price to be negotiated for each individual case.

2:12.4 All parts of the equipment shall be protected against damage or corrosion during and following any tests.

2:12.5 The OWNER and the ENGINEER shall have the right of representation at all shop tests and they shall be notified at least one (1) week in advance of all shop tests and inspection.

2:12.6 One (1) properly identified copy of the CONTRACTOR'S welding procedures, and other special fabrication data for the equipment, shall be submitted the ENGINEER for review and approval and three (3) copies shall be sent to the OWNER.

2:12.7 One (1) certified copy of all shop test data for the equipment, properly identified, shall be forwarded to the ENGINEER for acceptance, and three (3) copies shall be sent to the OWNER.

2:13 Shipment of Completed Work

All equipment shall be shipped completely factory assembled, except when the physical size, arrangement or configuration of the equipment, or shipping and handling limitations, make the shipment of completely assembled equipment impracticable.

2:14 Special Tools

2:14.1 The CONTRACTOR shall furnish one complete set of all special tools, all in first class condition, which will be required for maintenance of the equipment covered by the Contract. Identification of all tools by name and number shall be provided, and this number shall appear on drawings and instructions to indicate the application of the tools furnished and to permit ordering replacements.

2:14.2 The tools shall be shipped in a separate, heavily constructed, wooden box or boxes provided with hinged covers and padlock clasps. The boxes shall be marked with a large painted legend as follows:

Florida Power Corp. - Crystal River Unit No. 3

Maintenance Tools - (Name of equipment)

2:15 Protection During Shipment and Storage

2:15.1 Except as specified otherwise herein, exposed iron and steel surfaces of all equipment shall be given one coat of primer paint before shipment of the equipment to the job site. Before application of paint, all surfaces shall be free of rust, scale, lubricants, moisture, and other substances. Surfaces prepared for field welding shall be left unpainted for a distance of two inches from the weld. These surfaces shall be given a protective film of oil or other easily removed material to prevent rusting before erection.

2:15.2 The CONTRACTOR will be advised of the acceptable prime paint for exposed carbon steel surfaces of equipment and material to be installed inside the reactor building.

2:15.3 All exposed carbon steel surfaces of all other equipment shall be painted with zinc chromate pigment, rust inhibitive, metal primer paint recommended by the paint manufacturer for the service intended, and for application to metals prepared for painting by wire brushing. Paint shall be applied in accordance with the paint manufacturer's recommendations.

2:15.4 Machined surfaces such as shafts, pins, bushings, shaft couplings and other similar parts whose operation would be impaired by painting shall not be painted. These surfaces shall be protected by application of an easily removable rust preventative compound.

2:15.5 Plastics, corrosion resistant metals such as aluminum, brass, bronze, or stainless steel, and chrome plate or galvanized surfaces shall not be painted.

2:15.6 Each piece of equipment shall be cleaned thoroughly and dried prior to shipment. Equipment made of carbon steel shall contain adequate bags of silica-gel or approved equivalent desiccant to maintain a dew point of 40 F. Desiccant bags shall be securely anchored within the equipment. All openings of all equipment shall be closed prior to shipment with an easy to remove plug of suitable material.

2:15.7 All equipment and accessory items shall be suitably boxed, crated, wrapped or covered to the extent practicable, to prevent entrance of dirt or moisture and to prevent accidental damage during shipment to the job site and during outdoor storage at the job site. Where necessary a desiccant shall be included within the packing enclosure of items sensitive to changes in humidity.

2:15.8 All accessory items shall be shipped with the equipment. Boxes and crates containing accessory items shall be marked so that they are identified with the main equipment. The contents of the boxes and crates shall also be indicated.

2:16 Shipping Notices

2:16.1 The CONTRACTOR shall provide two copies of a shipping notice describing each shipment of material or equipment. The shipping notice shall be mailed on a schedule so that the notice will arrive approximately three days ahead of the estimated arrival time of the shipment.

2:16.2 The shipping notice shall be identified with the OWNER'S name, purchase order number, and name of the item of equipment or material.

The mailing address for the shipping notice is:

Florida Power Corporation
Crystal River Plant Unit No. 3
P. O. Box 276
Crystal River, Florida 32629

Attention: Mr. H. L. Bennett
Construction Manager

2:17 Patents

The CONTRACTOR shall satisfy all demands that may be made at any time for royalties and fees, and he shall be liable for any damages or claims, for patent infringements. The CONTRACTOR shall, at his own cost and expense, defend all suits or proceedings that may be instituted against the OWNER for infringement or alleged infringement of any patents involved in the WORK, and, in the case of an award of damages, the CONTRACTOR shall pay such award.

2:18 Conflicts

In the event of discrepancies between the detailed requirements of this Requirement Outline and those of the General Conditions, the detailed requirements shall prevail.

RO-3040
6-12-70
Amended
5-13-71
13

3:00 DETAILED SPECIFICATION

3:01 Scope of Work

The WORK to be performed under this Contract shall include the furnishing, fabrication, and delivering of the prestressing system tendon conduit for the Reactor Building for the Crystal River Plant, Unit No. 3, Florida Power Corporation. The WORK shall be as outlined herein and as shown on the Drawings and shall include, but not necessarily be limited to, the following:

1. Furnishing all materials required for the conduit, including temporary end caps, and protection required during transportation and delivery.

2. Delivering of conduit to the job site.

3. Furnish all necessary shop drawings for the related WORK.

3:02 General

3:02.1 The conduit system shall consist of Rigid, Flexible, and Schedule 40 conduit as indicated on the accompanying Florida Power Corporation drawings. The requirements under Items 3:02 through 3:05 and 3:09 of this Requirement Outline shall apply to the three types of conduit. Specific requirements for Rigid, Flexible, and Schedule 40 conduit are indicated in Items 3:06, 3:07 and 3:08 respectively.

3:02.2 The conduit shall be delivered to the site, complete with temporary end caps, in a clean condition, i.e., both surfaces free of debris and deleterious substances. The CONTRACTOR shall submit details of the proposed temporary end caps to the OWNER and ENGINEER for approval.

3:02.3 Upon delivery to the site, the conduit shall be inspected by the OWNER for detrimental splits, cuts, and dents. In order to determine if a dent is detrimental, a wooden pig of 4-3/4 inches diameter shall be pulled through the conduit. Should a dent or dents restrict the passage of the pig, the conduit will be rejected and shall be replaced at no additional cost to the OWNER. Should the conduit be delivered with any splits or cuts which completely penetrate the wall of the conduit, it shall be rejected and replaced at no additional cost to the OWNER. Conduit delivered with splits and cuts which do not completely penetrate the wall may be accepted by the OWNER if it can be shown that the performance criteria called for in this Requirement Outline can be met and if the galvanizing coating can be repaired. Schedule 40 conduit with painted ends and couplings shall be inspected for damage to galvanized and painted surfaces. For this case any damage which cannot be satisfactorily repaired by the OWNER will be rejected and replaced by the CONTRACTOR at no additional cost to the OWNER.] A

3:02.4 The dimensional tolerances for cutting and bending the Rigid and Schedule 40 conduit shall be:

1. radius: ± 1/4 in.
2. length after bending: ± 1/2 in.
3. square cut at ends, measured with "L" square and feeler gauge: ± 1/16 in.

3:02.5 At the square cut ends of the conduit, any burr at the cut shall be removed to give smooth interior and exterior surfaces.

3:03 Material

The conduit shall be made from steel. The material specification shall be subject to approval by the OWNER and ENGINEER. The CONTRACTOR shall supply to the OWNER prior to shipment of the conduit to the jobsite, mill certificates for the chemical properties of the steel, for each heat of steel, used in the manufacture of the conduit.

3:04 Performance Criteria

3:04.1 The conduit shall be so constructed that a hydrostatic pressure of 10 psig can be maintained without leaking water when the conduit is bent to the minimum radius shown on the Florida Power Corporation drawings. The conduit may be subjected to field pressure testing by Others upon receipt of the conduit. Any conduit failing to meet this criterion will be rejected and replaced by the CONTRACTOR at no additional cost to the OWNER.

3:04.2 The conduit, when continuously supported on a flat surface, shall be sufficiently strong to withstand, without permanent deformation, the weight of a two hundred pound man.

3:04.3 Recognition must be given to the fact that the entire conduit system will be connected to the station grounding system by cad-welding a standard bare copper wire minimum No. 4/0 AWG to all tendon anchorage components, to provide a continuous conducting path throughout the entire tendon conduit system.

3:05 Corrosion Protection

3:05.1 Both surfaces of the conduit shall be galvanized using the hot dip method of application. After bending, the galvanizing application must adhere to the surface of the conduit.

3:05.2 After fabrication has been completed, temporary end caps shall be placed over each end of each section of conduit. These end caps must be securely fixed to the end of the conduit so that normal transportation, handling, etc. will not cause them to be removed or enter the inside of the conduit. The conduit must be clean and dry prior to placing the end caps.

3:06 Rigid Conduit

3:06.1 Rigid conduit shall be round mechanical welded steel tubing 5-1/4 inch O. D. and shall have a minimum wall thickness of 0.065 inches and a minimum I.D. of 5 inches. Conduit shall be manufactured according to ASTM A 513-69, "Standard Specifications for Resistance Welded Steel Tubing." The supplemental requirement of non-destructive Electric Test on the welded seam will be required for all conduit.

3:06.2 Rigid conduit shall be accurately cut and bent to the dimensional requirements as shown on the Florida Power Corporation drawings. Rigid conduit shall have belled ends as detailed and located on the drawings. Quantities of rigid conduit to be supplied under this contract shall be as indicated on the drawings and in this Requirement Outline.

3:06.3 The CONTRACTOR shall provide shop drawings and lists for conduit fabrication and identification, for each length of conduit. Shop drawings shall provide all dimensional information required to fabricate and identify the conduit. Shop drawings shall be submitted to the ENGINEER for approval.

3:06.4 A conduit numbering and identification system will be developed by the OWNER, ENGINEER and CONTRACTOR. Each length of conduit shall be clearly marked with this number for identification on the job site.

3:06.5 In addition to the conduit quantities represented on the drawings, the CONTRACTOR shall supply with the first shipment of Rigid conduit the following stock lengths of conduit, each of which shall have one end belled:

1. Straight conduit - 20 lengths @ 20 feet each, total 400 lineal feet.

   - 20 lengths @ 10 feet each, total 200 lineal feet

2. Bent conduit (67' 8-5/8" radius) - 20 lengths @ 30 feet each, total 600 lineal feet.

   - 20 lengths @ 20 feet each, total 400 lineal feet.

3:07 Flexible Conduit

3:07.1 Flexible conduit must be capable of being bent by hand to the radii shown on the Florida Power Corporation drawings. Flexible conduit shall be 5 inches I. D. and 5-1/4 inches O.D., minimum 22 gauge (0.028) galvanized steel.

3:07.2 Gasketing materials shall be incorporated in the conduit if necessary to meet the leak-tightness criteria. The gasketing materials shall not decompose when subjected to site weathering and shall be subject to approval by the OWNER and the ENGINEER. The CONTRACTOR shall supply a sample length of the proposed conduit, upon request of the OWNER or ENGINEER, prior to award of contract.

3:07.3 Flexible conduit will be supplied to the job site in 50 foot lengths. The conduit will be cut to length in the field by Others.

3:07.4 The CONTRACTOR shall hydrostatically test the Flexible conduit, to verify conformance with the pressure criterion listed under item 3:04.1. The tests shall be conducted on production samples of conduit, bent to a minimum radius of 20 feet 0 inches. The frequency of conduit testing shall be a minimum of 10% of the total shipment or shop order, randomly distributed over the total footage. The OWNER and ENGINEER shall have access to witness all testing. Test records shall be kept and forwarded to the OWNER and ENGINEER.

3:08 Schedule 40 Conduit

Note: Schedule 40 conduit shall be used in the mat and the dome of the reactor building. The requirements for the Schedule 40 conduit in the mat are noted in items 3:08.1 through 3:08.4 inclusive, and the requirements for the Schedule 40 conduit in the dome are noted in items 3:08.3 through 3:08.7 inclusive. A

3:08.1 The conduit shall be galvanized round steel pipe, 5 inch I. D. Schedule 40, types E or S, grade A, conforming to ASTM A 53-70, "Welded and Seamless Steel Pipe."

3:08.2 The Schedule 40 conduit shall be accurately cut and bent to the dimensional requirements as shown on the Florida Power Corporation drawings. The Schedule 40 conduit shall have sleeve type welded couplings as detailed and located on the drawings. Quantities of Schedule 40 conduit to be supplied under this Contract shall be as indicated on the drawings and in this Requirement Outline.

3:08.3 The CONTRACTOR shall provide shop drawings and lists for conduit fabrication and identification for each length of conduit. Shop drawings shall provide all dimensional information required to fabricate and identify the conduit. Shop drawings shall be submitted to the ENGINEER for approval.

3:08.4 A conduit numbering and identification system will be developed by the OWNER, ENGINEER and CONTRACTOR. Each length of conduit shall be clearly marked with this number for identification at the job site.

3:08.5 The dome conduit shall be galvanized round steel pipe, 5 inch nominal diameter Schedule 40, types E or S, grade B wall thickness 0.258 inches, conforming to ASTM A 53-70, "Welded and Seamless Steel Pipe."]B

3:08.6 The dome conduit shall be accurately cut and bent to the required dimensions and as shown on the drawings accompanying this Requirement Outline. The CONTRACTOR shall locate the joints in a dome conduit run (a dome conduit run is from trumpet to trumpet for a particular tendon) to suit his manufacturing and handling requirements, provided he complies with the following:

1. Joints shall <u>not</u> be made at the intersection of conduits.

2. Joint location adjacent to the ring beam shall be as shown on drawing number SC-400-019 "Reactor Building - Dome Conduit Splice Locations Required Adjacent to Ring Beam."

3. The minimum length of a section of dome conduit shall be 20'-0". The dome is defined as that area within a horizontal radius from the centerline of reactor building of 55'-5-1/2". A

Quantities of Schedule 40 conduit to be supplied under this Contract shall be as indicated on the drawings.

3:08.7 Sections of dome conduit shall be joined together at each joint, with a sleeve type coupling. All sleeve couplings shall be made from round steel pipe, 6 inch nominal diameter, types E or S, grade B, wall thickness 0.432 inches, conforming to ASTM A 53-70.]B Details of the couplings are shown on drawing SC-400-019. The CONTRACTOR shall weld onto one end of each section of conduit a coupling, except for the section of the conduit which is nearest to the apex of the dome of each conduit run. For this latter case the CONTRACTOR shall forward to the job site sufficient loose couplings to allow installation of the apex section of conduit. The welds shall be fillet type and shall develop the full strength of the conduit. The CONTRACTOR shall submit details of the weld to the OWNER and the ENGINEER for approval. The CONTRACTOR'S welders, who are to perform the shop welding, shall be qualified in accordance with the recommendations of AWS D1.0. The CONTRACTOR shall develop written welding work procedures and submit them to the OWNER and the ENGINEER for approval. The work procedures shall also include:

1. Removal of galvanizing from weld area on outside of the conduit.

2. 10% random liquid penetrant inspection of the shop welds.

3. Hydrostatic pressure testing of the weld to ensure leak tightness, to the criteria noted in Item 3:04. The frequency of testing shall be a minimum of 10% of the couplings, selected at random.

4. Painting inside and outside of the coupling and the ungalvanized and heat effected areas of the conduit. The type of paint used shall be capable of preventing corrosion of the conduit for a minimum period of 1-1/2 years, when exposed to the job site environment. The CONTRACTOR shall submit details of the paint to the OWNER for approval.

A

3:09 Quality Control

The CONTRACTOR shall furnish to the OWNER:

1. Procedures for control and materials and conduit dimensions, during fabrication, handling, and shipping.

2. The specification of materials used in the conduit.

3. Mill certificates for the steel and associated fabrication and all testing records, prior to shipment to the job site.

4. Develop written work procedures for welding couplings to the conduit. Refer to item 3:08.7.

A

RIGID CONDUIT
Delivery Schedule and Proposal Information

A. Initial delivery of conduit to the job site shall be made in September 1970. Delivery of all conduit shall be completed by February 1971. Conduit shall be delivered in a minimum of three shipments with the conduit in the lower wall sections delivered first and the conduit for the upper wall sections delivered last. A detailed delivery schedule shall be prepared by the CONTRACTOR and furnished to the OWNER for approval.

B. Total payment shall be determined by applying the quoted unit prices to the total quantities delivered and accepted for use on the job site. Unit prices shall include all provisions of these specifications and drawings including belled ends, bends, delivery, and quality control requirements.

C. Base Bid. Unit prices shall be furnished to the Owner with the proposal for fabrication and delivery of rigid conduit as specified herein (.065" minimum wall thickness) for the following types of conduit:

1. Vertical conduit (straight) . . . . .$_____ per lineal ft.

2. Horizontal conduit (67'-8 5/8" radius) $_____ per lineal ft.

D. Alternate No. 1. Unit prices shall be furnished to the Owner with the proposal for fabrication and delivery of the following types of rigid conduit with a minimum wall thickness of .083 inches in lieu of that specified with all other provisions of the specification remaining applicable:

1. Vertical conduit (straight) . . . .$_____ per lineal ft.

2. Horizontal conduit (67'-8 5/8" radius) $_____ per lineal ft.

E. An estimate of the following total conduit quantities shall be furnished with the proposal including the stock quantities mentioned in the specifications. These estimated quanitites will not be used to determine total payment but are intended to evaluate the Contractor's understanding of the intended scope of work.

1. Vertical conduit (straight) . . . . . ._____ lineal ft.

2. Horizontal conduit (67'-8 5/8" radius) . ._____ lineal ft.

F. The following Florida Power Corporation drawings accompany this Requirement Outline:

CR#-S21-E-0 thru CR3-S57-E-0.

ADDENDUM A

Sheet 1 of 3
May 13, 1971

3:00 DETAILED SPECIFICATION

3:02 General

3:02.3 After the word "repaired." add the following:

"Schedule 40 conduit with painted ends and couplings shall be inspected for damage to galvanized and painted surfaces. For this case any damage which cannot be satisfactorily repaired by the OWNER will be rejected and replaced by the CONTRACTOR at no additional cost to the OWNER."

3:08 Schedule 40 Conduit

Before item 3:08.1 add the following:

"Note: Schedule 40 conduit shall be used in the mat and the dome of the reactor building. The requirements for the Schedule 40 conduit in the mat are noted in items 3:08.1 through 3:08.4 inclusive, and the requirements for the Schedule 40 conduit in the dome are noted in items 3:08.3 through 3:08.7 inclusive."

Add the following items:

"3:08.5 The dome conduit shall be galvanized round steel pipe, 5 inch nominal diameter, Schedule 40, types E or S, grade A, wall thickness 0.258 inches, conforming to ASTM A 53-70, "Welded and Seamless Steel Pipe."

"3:08.6 The dome conduit shall be accurately cut and bent to the required dimensions as shown on the drawings accompanying this Requirement Outline. The CONTRACTOR shall locate the joints in a dome conduit run (a dome conduit run is from trumpet to trumpet for a particular tendon) to suit his manufacturing and handling requirements, provided he complies with the following:

1. Joints shall not be made at the intersection of conduits.

2. Joint location adjacent to the ring beam shall be as shown on drawing number SC-400-019 "Reactor Building - Dome Conduit Splice Locations Required Adjacent to Ring Beam."

ADDENDUM A

Sheet 2 of 3
May 13, 1971

3. The minimum length of a section of dome conduit shall be 20'-0". The dome is defined as that area within a horizontal radius from the centerline of the reactor building of 55'-5-1/2".

Quantities of Schedule 40 conduit to be supplied under this Contract shall be as indicated on the drawings.

"3:08.7 Sections of dome conduit shall be joined together at each joint, with a sleeve type coupling. All sleeve couplings shall be made from round steel pipe, 6 inch nominal diameter, types E or S, grade A, wall thickness 0.432 inches, conforming to ASTM A 53-70. Details of the couplings are shown on drawing SC-400-019. The CONTRACTOR shall weld onto one end of each section of conduit a coupling, except for the section of conduit which is nearest to the apex of the dome of each conduit run. For this latter case the CONTRACTOR shall forward to the job site sufficient loose couplings to allow installation of the apex section of conduit. The welds shall be fillet type and shall develop the full strength of the conduit. The CONTRACTOR shall submit details of the weld to the OWNER and the ENGINEER for approval. The CONTRACTOR'S welders, who are to perform the shop welding, shall be qualified in accordance with the recommendations of AWS D1.0. The CONTRACTOR shall develop written welding work procedures and submit them to the OWNER and the ENGINEER for approval. The work procedures shall also include:

1. Removal of galvanizing from weld area on outside of the conduit.

2. 10% random liquid penetrant inspection of the shop welds.

3. Hydrostatic pressure testing of the weld to ensure leak tightness, to the criteria noted in Item 3:04. The frequency of testing shall be a minimum of 10% of the couplings, selected at random.

4. Painting inside and outside of the coupling and the ungalvanized and heat effected areas of the conduit. The type of paint used shall be capable of preventing corrosion of the conduit for a minimum period of 1-1/2 years, when exposed to the job site environment. The CONTRACTOR shall submit details of the paint to the OWNER for approval."

ADDENDUM A

Sheet 3 of 3
May 13, 1971

3:09 Quality Control

Add the following subitem:

"4. Develop written work procedures for welding couplings to the conduit. Refer to item 3:08.7."

NOTE: Attached hereto are amended pages 13, 16, and 17 and appended page 18 (dated May 13, 1971) which have had incorporated into them the changes made to the Requirement Outline by this Addendum. The pages have marginal notations indicating where the Addendum changes occur. Please replace old pages with these attached amended pages.

ADDENDUM B

Sheet 1 of 1
November 17, 1971

The following changes are set forth to amended page 17 issued to you under ADDENDUM A dated May 13, 1971.

3:00 DETAILED SPECIFICATION

3:08 Schedule 40 Conduit

3:08.5 Line 2:

Delete the "A" after the eighth word "grade" and replace with the following:

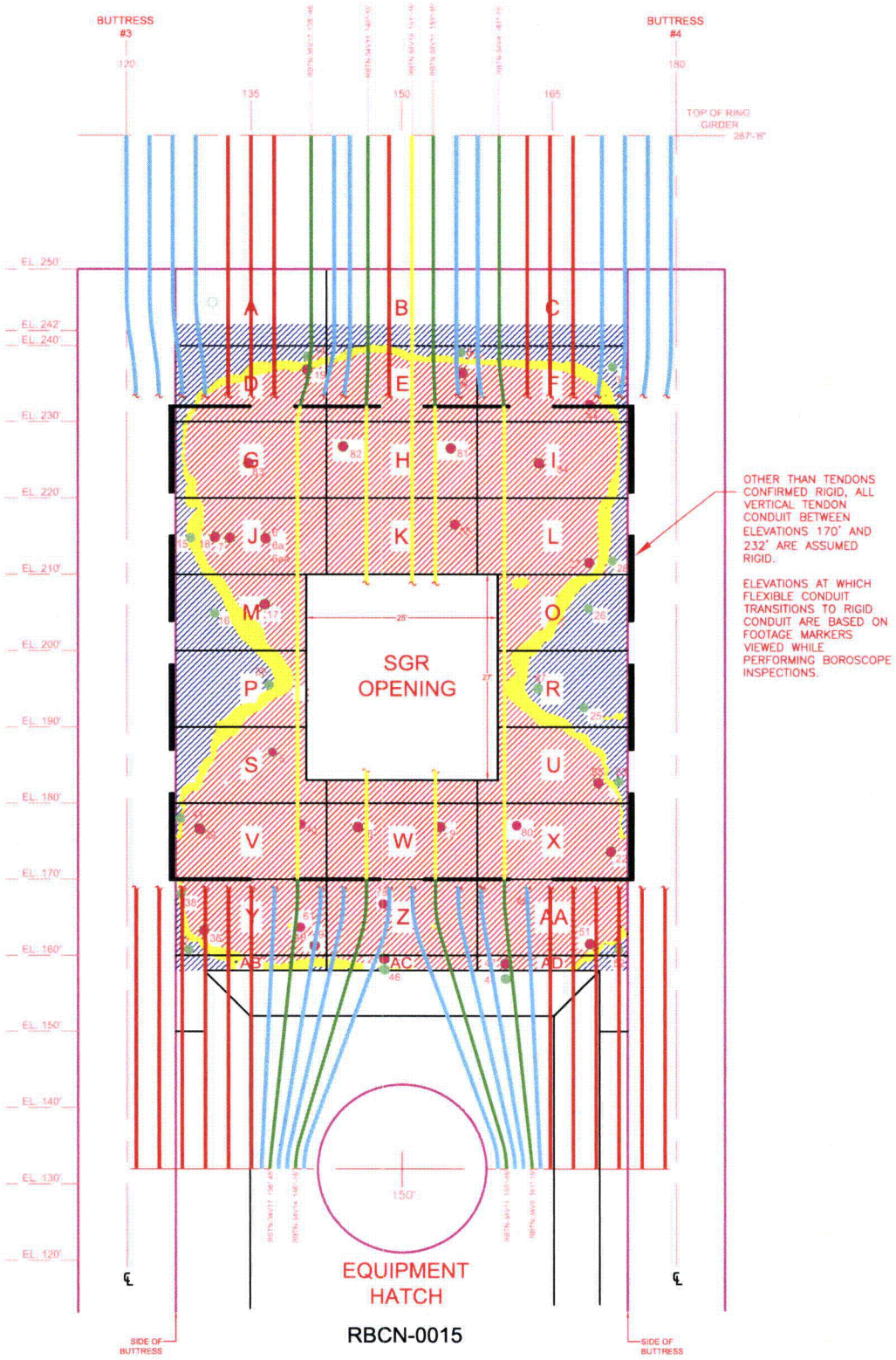
"B"

3:08.7 Line 4:

Delete the "A" after the first word "grade" and replace with the following:

"B"

NOTE: Attached hereto is amended page 17 which has had incorporated into it the changes set forth by this ADDENDUM B. The page has marginal notations indicating where the ADDENDUM B changes occur. Please replace old page with this attached revised page, dated November 17, 1971.



RBCN-0015

FIG. 4 - RIGID/FLEXIBLE VERTICAL TENDON LAYOUT

ASSUMED FLEXIBLE

CONFIRMED FLEXIBLE

ASSUMED RIGID

CONFIRMED RIGID

NO.	DESCRIPTION	DRAWN
A	ISSUED PER EC 74801	

REVISIONS

NUCLEAR ENGINEERING

CRYSTAL RIVER

Rigid Horizontal Tendon Sleeves

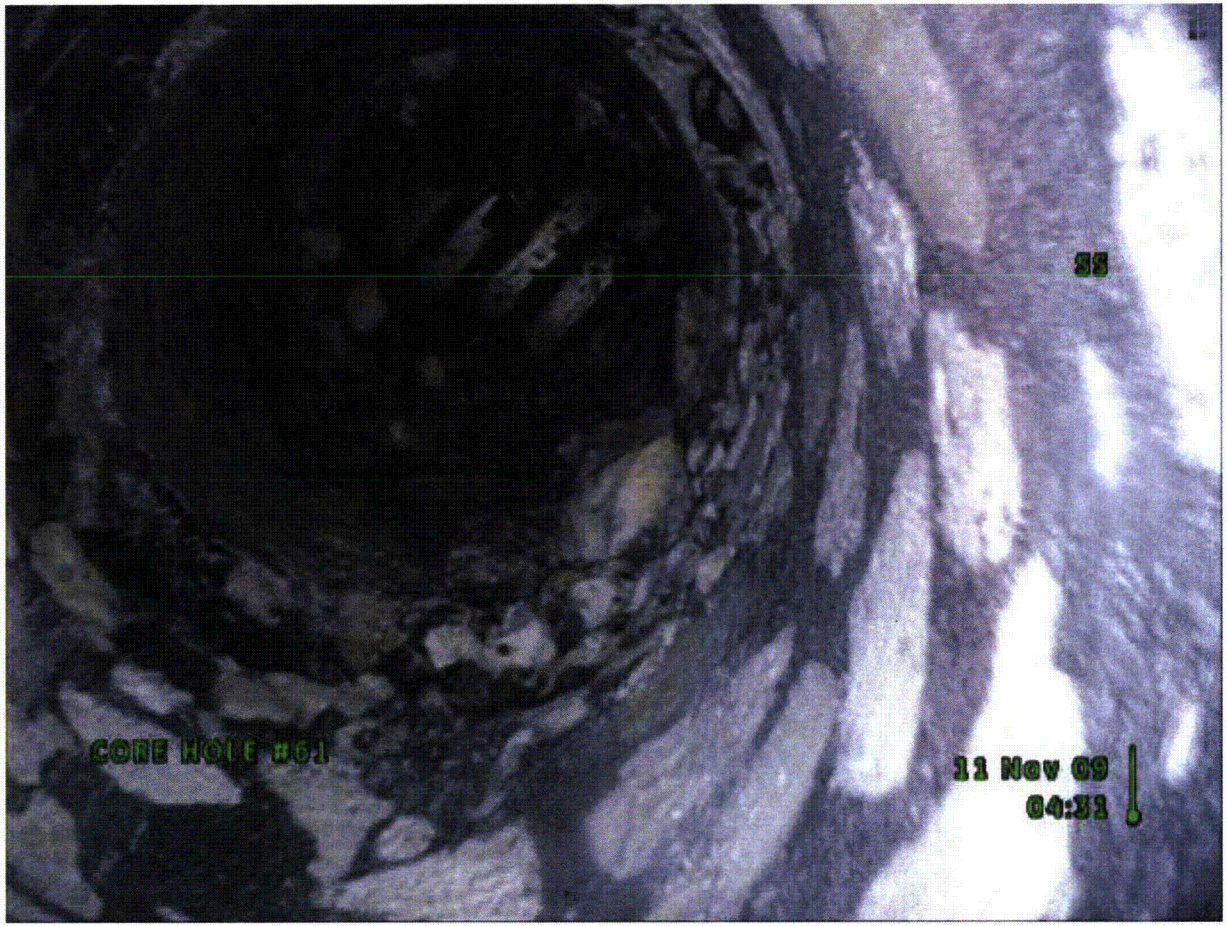
Horizontal tendon sleeves are rigid with a 0.08" wall thickness. Photograph of CR3 containment taken during hydro-blasting.

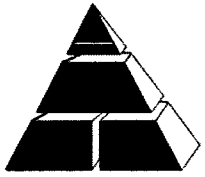
Rigid Horizontal and Vertical tendon sleeves

Horizontal tendon sleeves are rigid with a 0.08" wall thickness. Photograph of CR3 containment taken during hydro-blasting.

Flexible Tendon Sleeves

Observation of flexible sleeve inside core bore #61

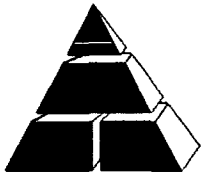




Modal Analysis, Transient Dynamic Response, and Stress Analysis of Concrete and Exposed Hoop Conduit due to Oscillating Hydro Cutting Load

Performance Improvement International

January 14, 2010



3-Step Approach

1. Frequency Analysis of ½ Symmetric Structure
2. ½ Symmetric Transient Dynamic Modal Dynamic Response due to Oscillating Hydro Cutting Load. Reaction Moment Calculated.
3. Detailed Stress Modeling of Small Section of Conduit in Concrete Wall. Loaded with Reaction Moment Results from Step 2

Assumptions

- Opening is 25 feet wide
- Hoop Tendon Conduit is Embedded in Concrete on both sides (½ Symmetric Model)
- Vertical Component @ 5° of two Nozzles of the Hydro Cutters are assumed acting in the downwards direction at the middle of the Exposed Hoop Tendon Conduit
- Radial load is not considered since Vertical Conduits give Support in this Direction

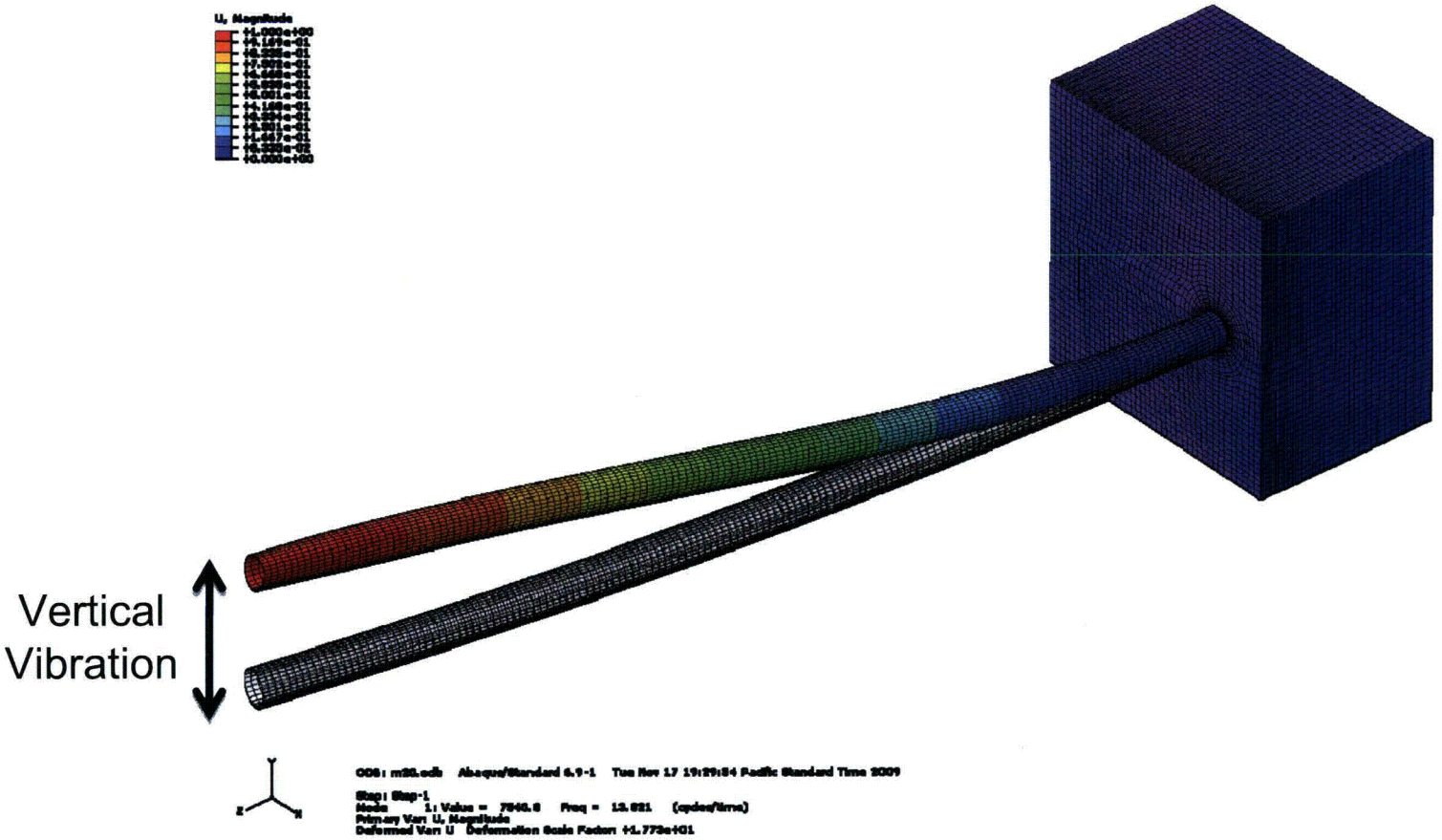
Assumptions (Cont.)

- Modeled using beam elements with Pipe Section (OD=5.25", ID=5")
- Curvature Modeled
- Steel Properties
- 17,000 psi Water Pressure @ 500 rpm rotation
- 2 Nozzles acting on Hoop Conduit @ Midpoint
- 2% of Critical Modal Damping
- Max Reaction Moment at Wall Calculated

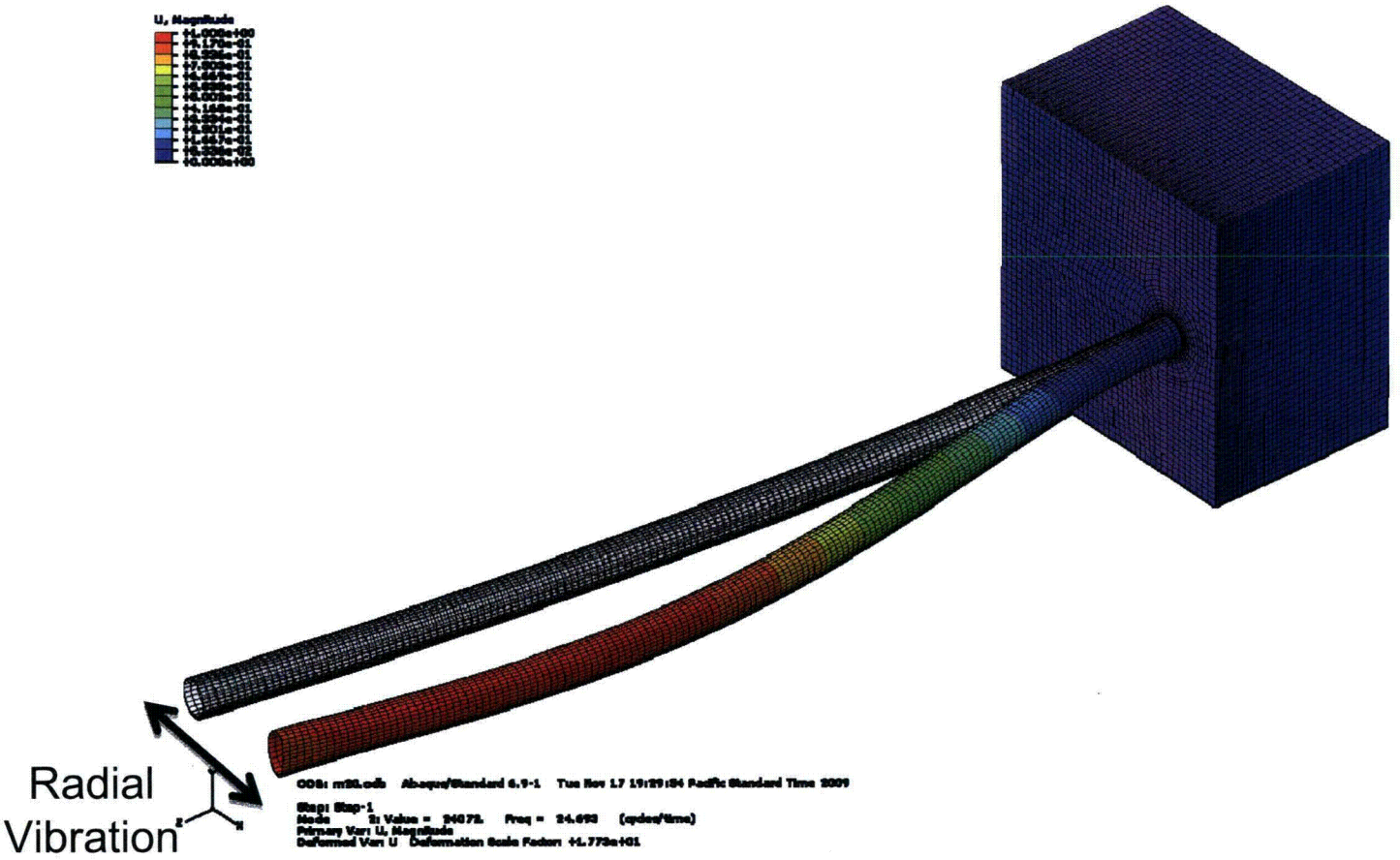
Frequency Summary

- The Hoop Tendon Conduit Natural Frequencies are:
  - Mode 1: 14 Hz (Vertical Direction)
  - Mode 2: 25 Hz (Radial Direction)

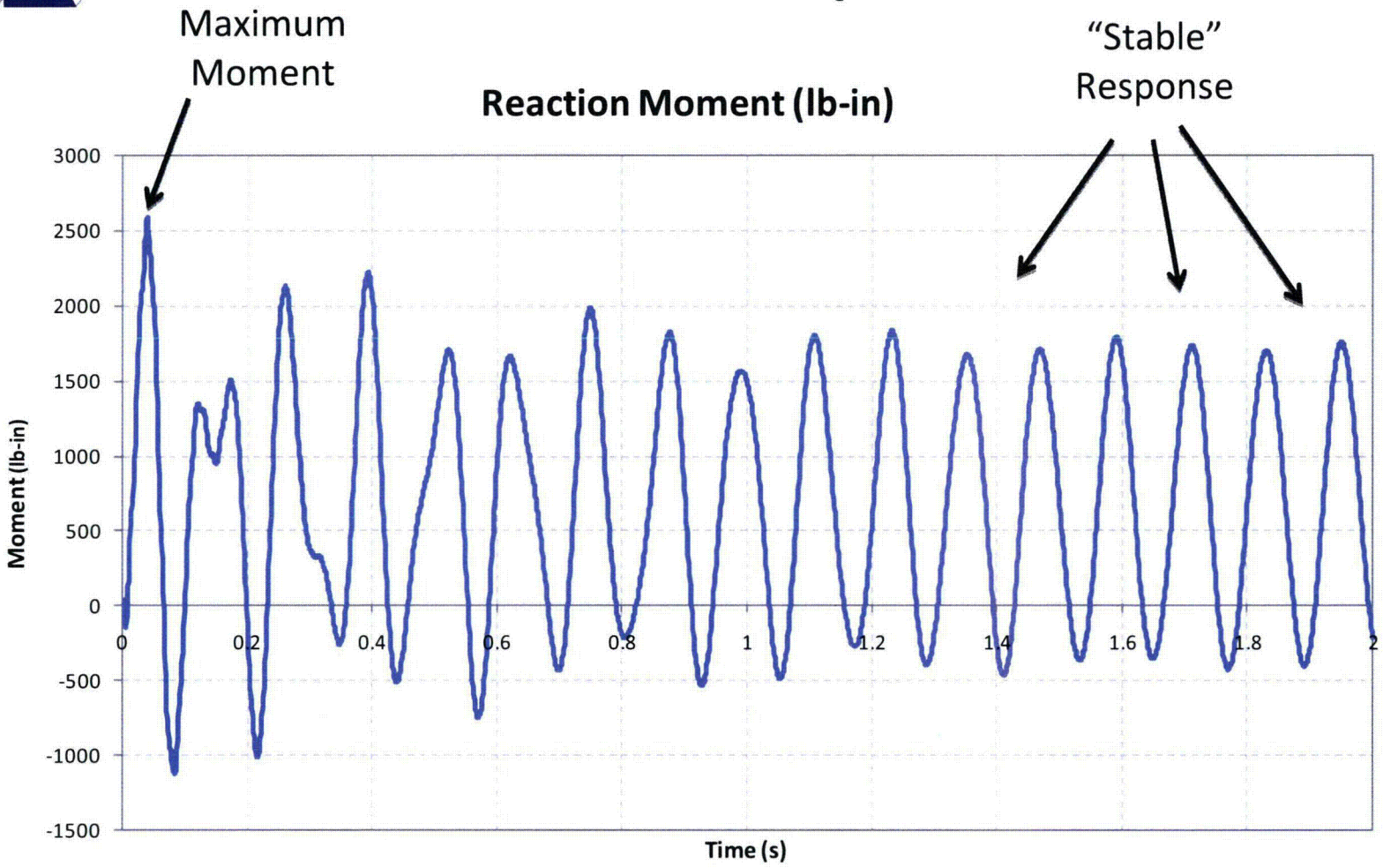
Mode 1 - 14 Hz



Mode 2 - 25 Hz



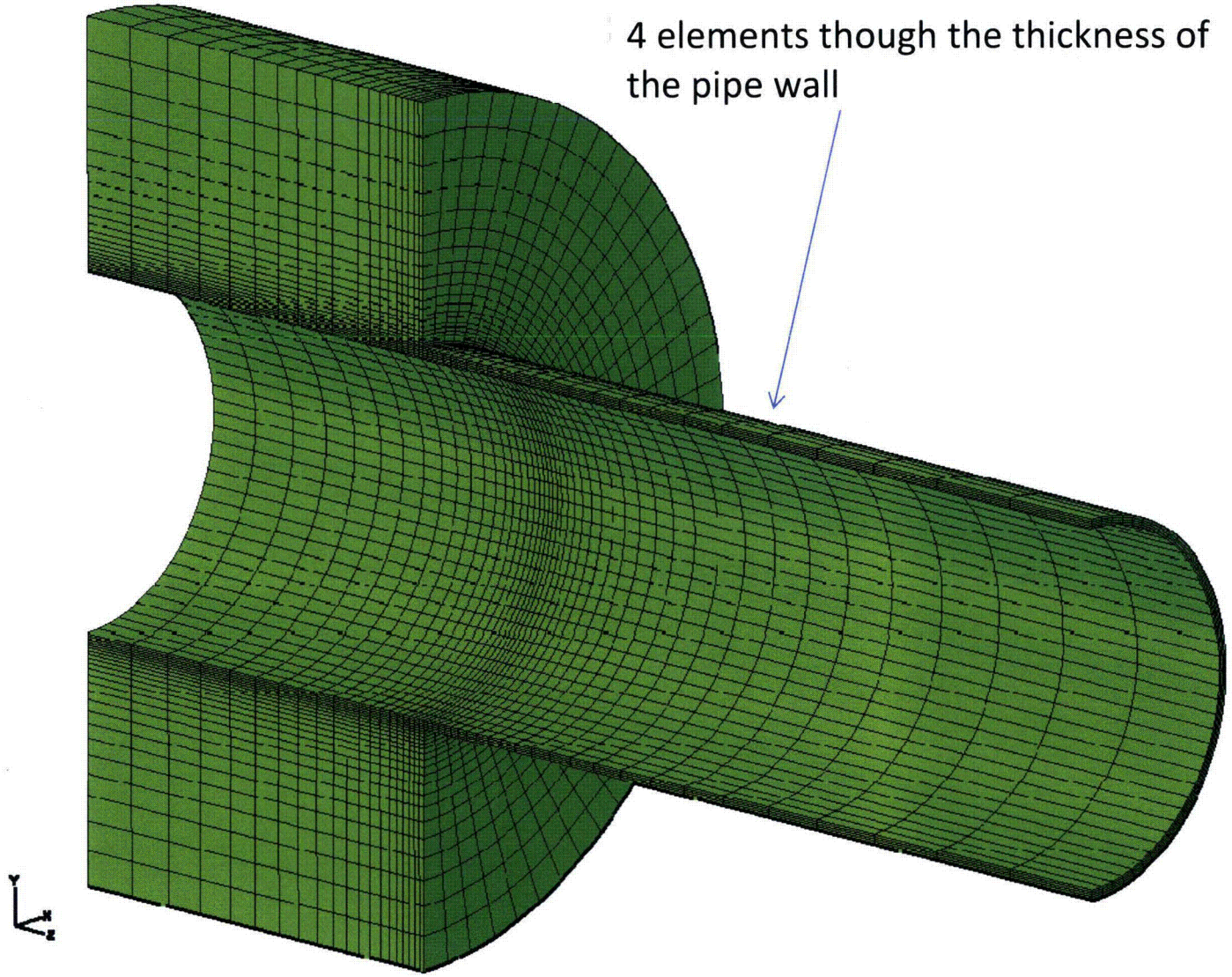
Transient Response



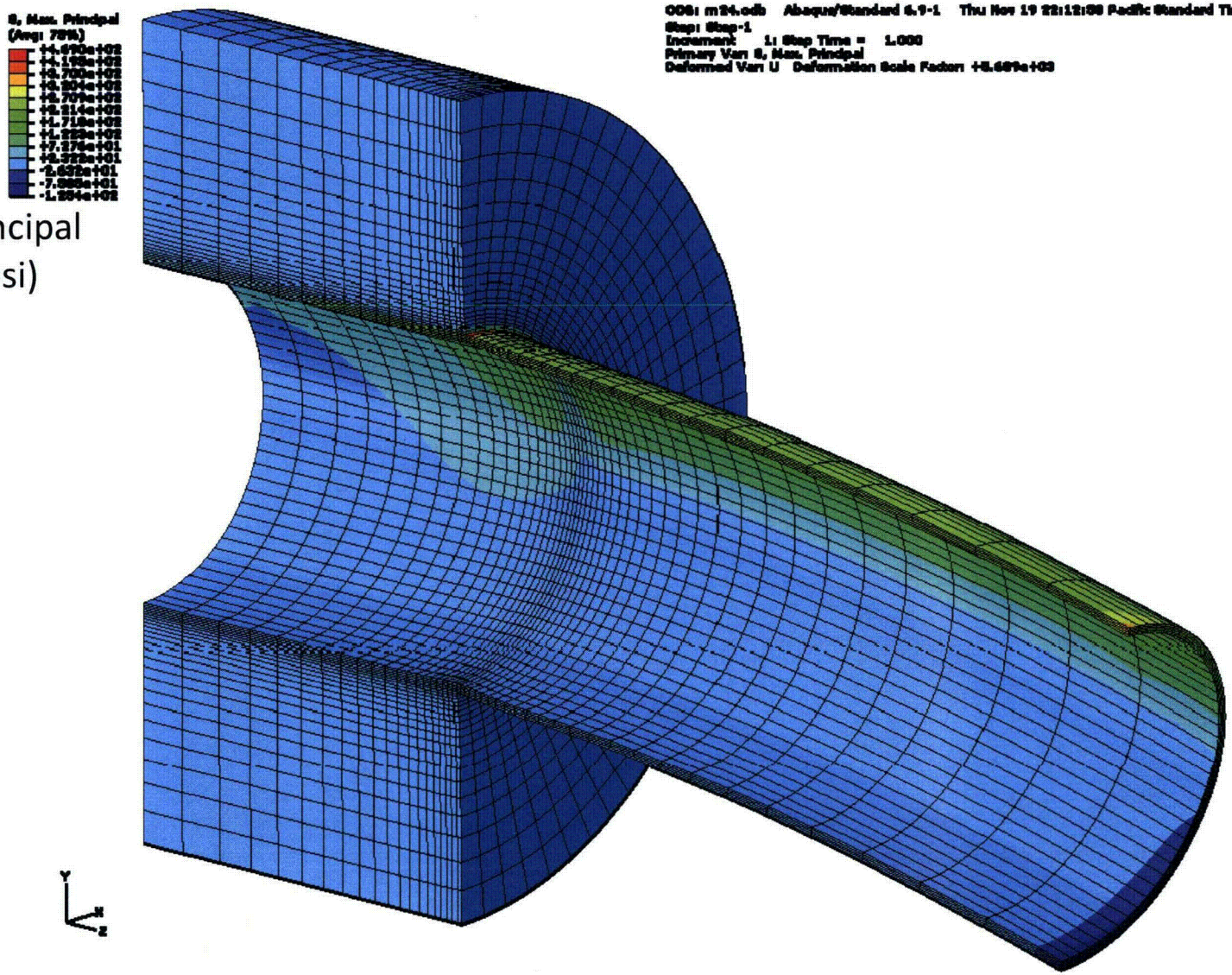
Detailed Stress Model Description

- 100% Quadratic Brick Elements
- Half Symmetry of "One Side"
- Curvature Ignored
- Only a 12" Section of the Conduit is Modeled
  - Moment Applied to the End Section based on Transient Dynamic Response
- Steel Conduit is Perfectly bonded to the Concrete
- Young's Modulus of Concrete: 2.5 E+6 psi

Detailed Stress Model Mesh

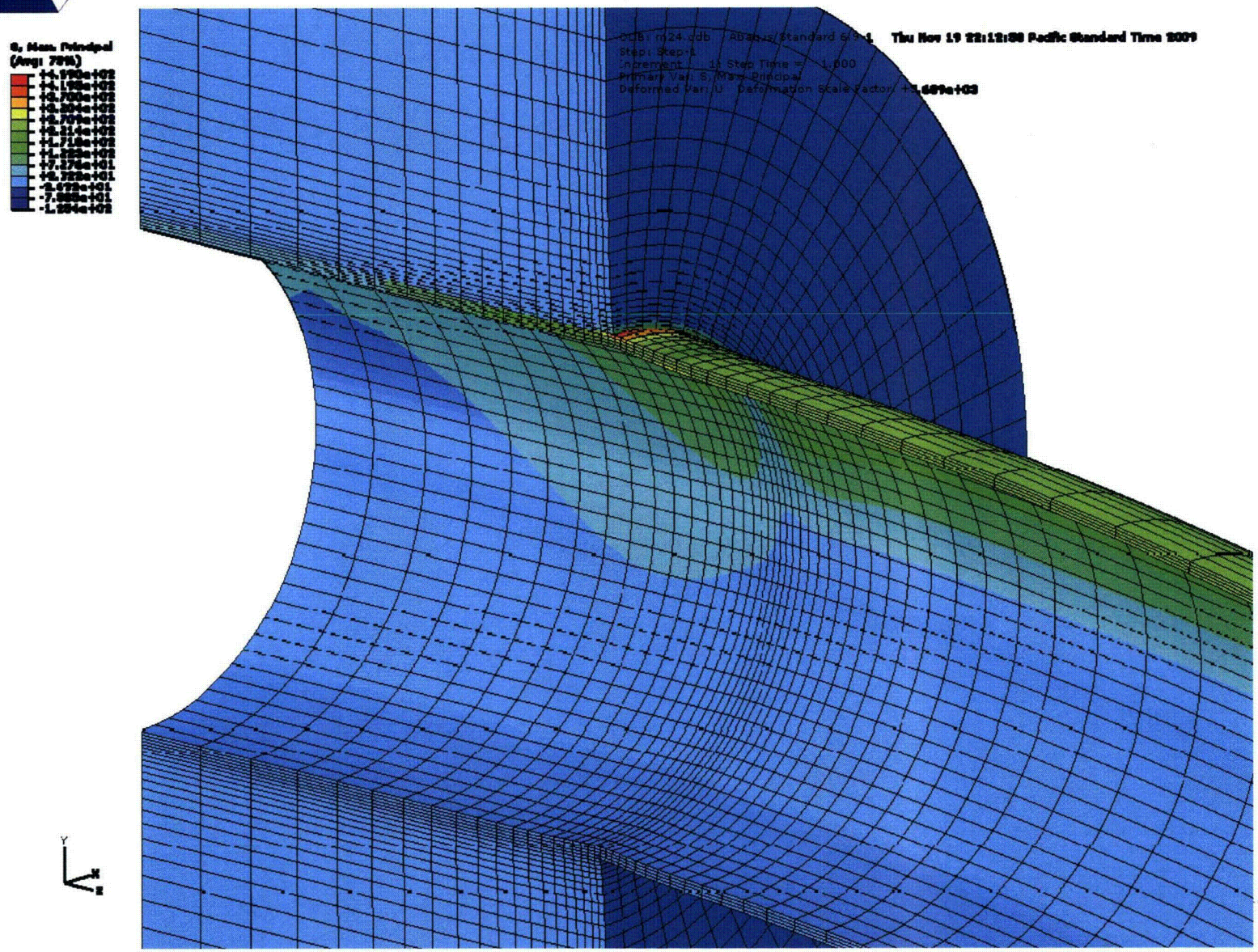


Steel and Concrete

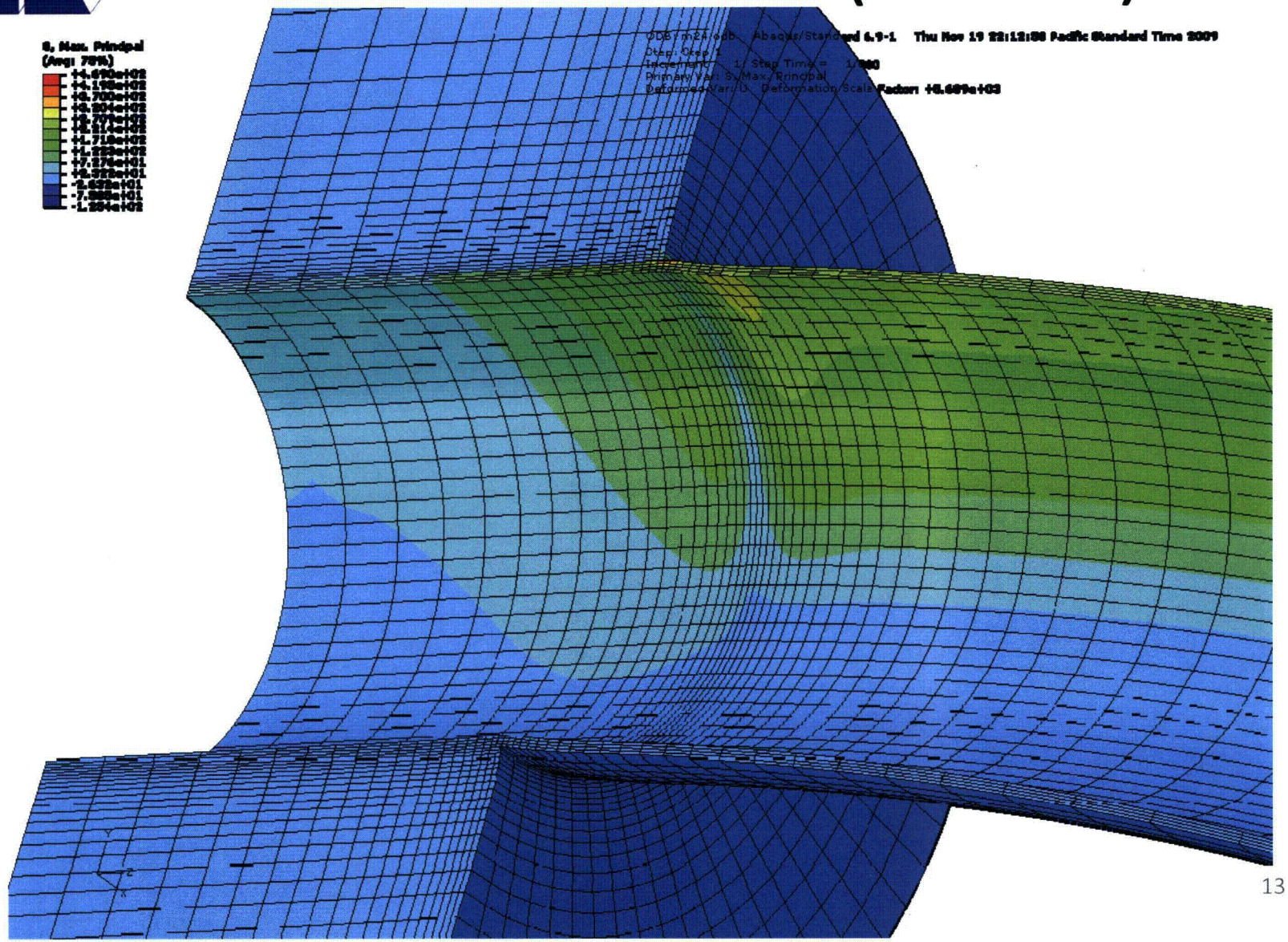


Max Principal Stress (psi)

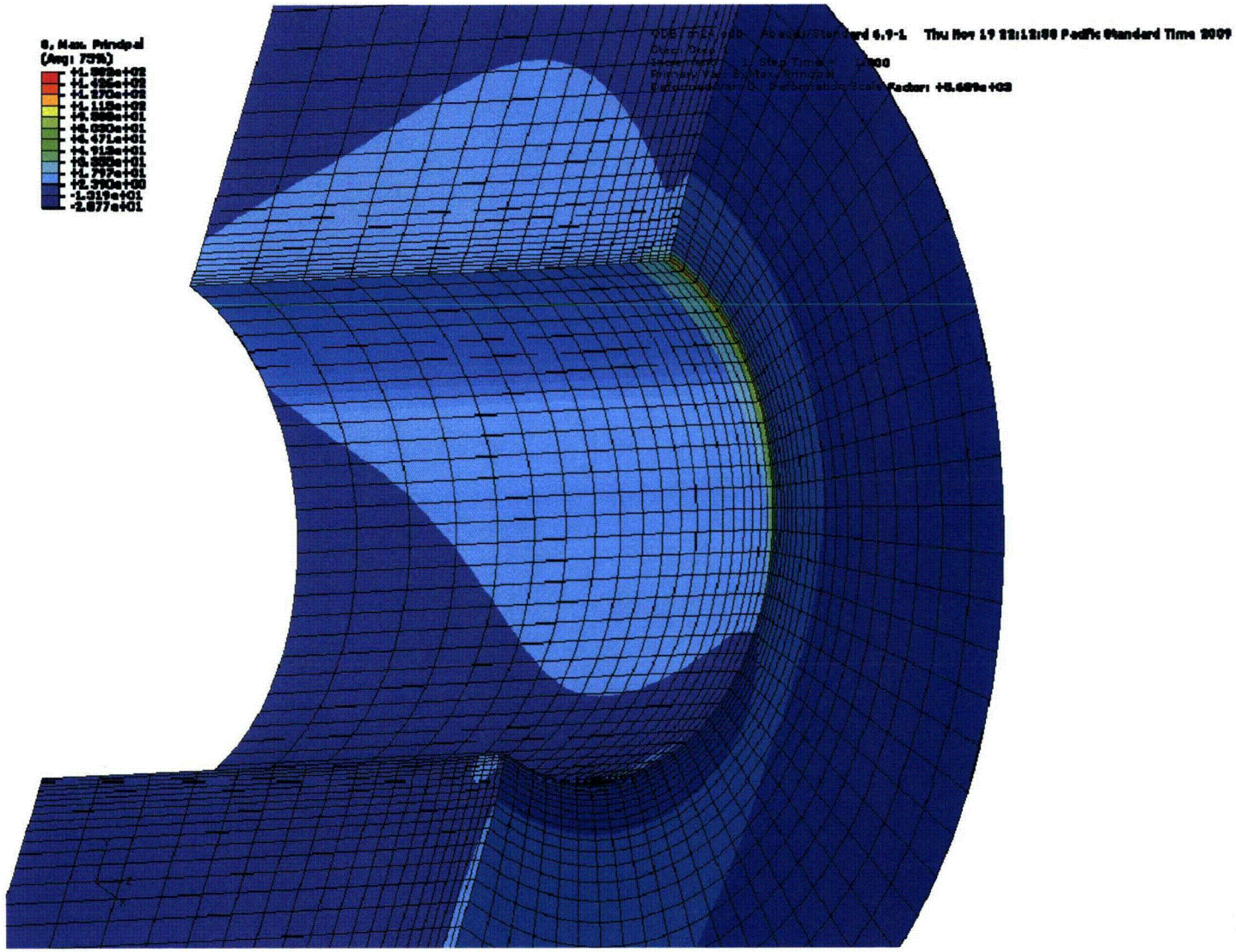
Steel and Concrete Interface



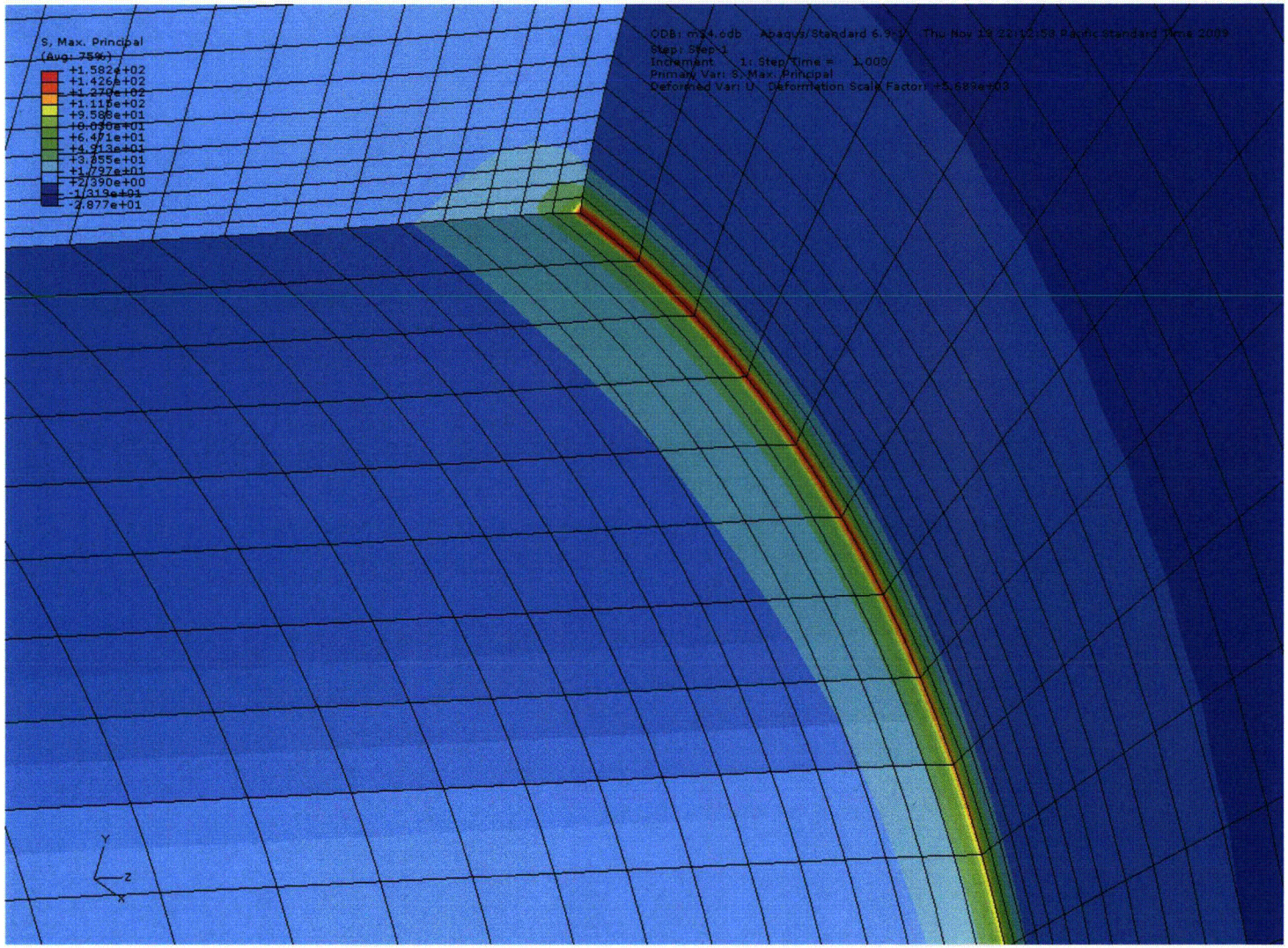
Steel and Concrete (View 2)

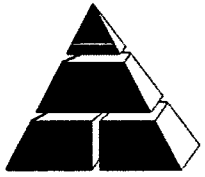


Concrete Stress Concentration



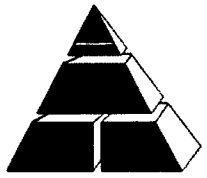
Detail of Concrete Stress





Stress Summary

- Maximum Principal Stress in Concrete Wall
  - Less than 160 psi Tensile

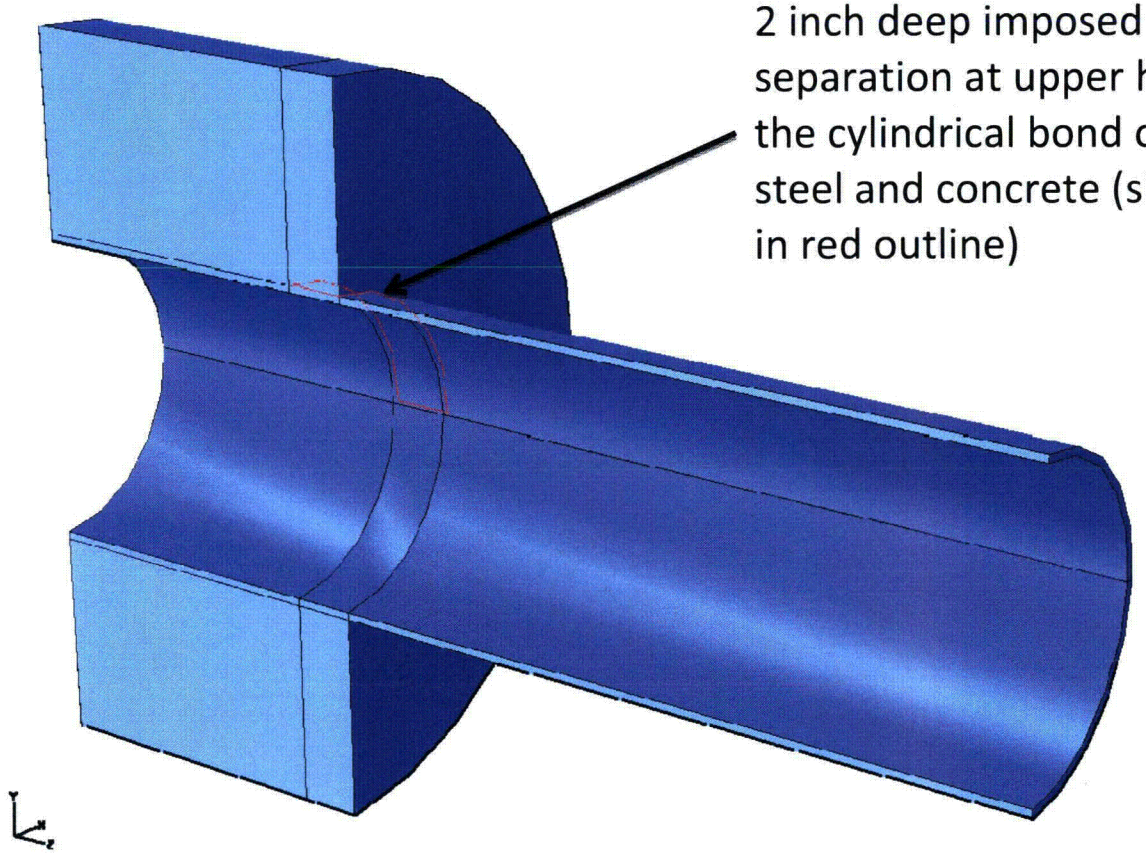


Local Separation of Conduit from Concrete Wall

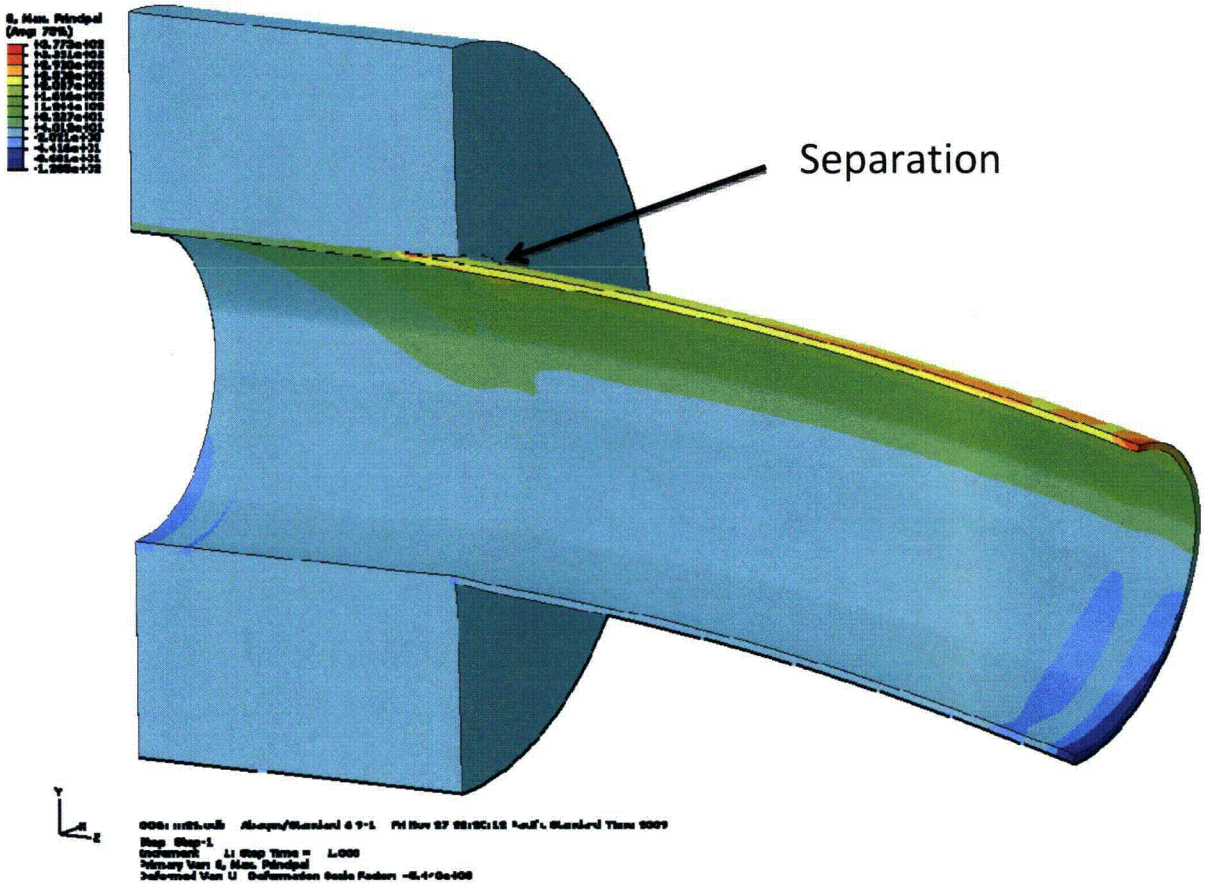
Justification/Approach

- Stress concentration at the corner of Conduit and Concrete Wall may cause local separation of Conduit from the Concrete Wall which will lower the stress concentration
- Study an imposed 2 inch deep separation of top half of the Conduit
- Assess stress

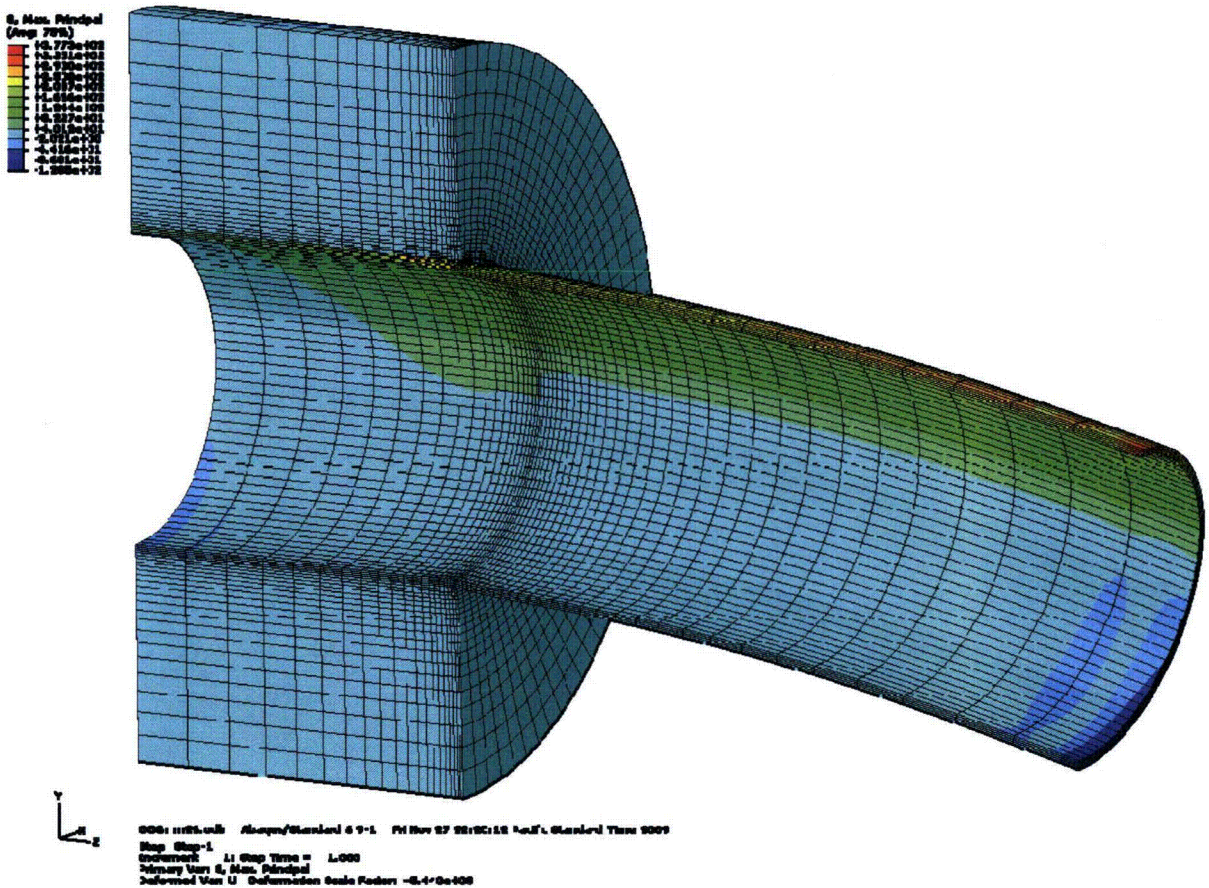
Conduit/Concrete Separation



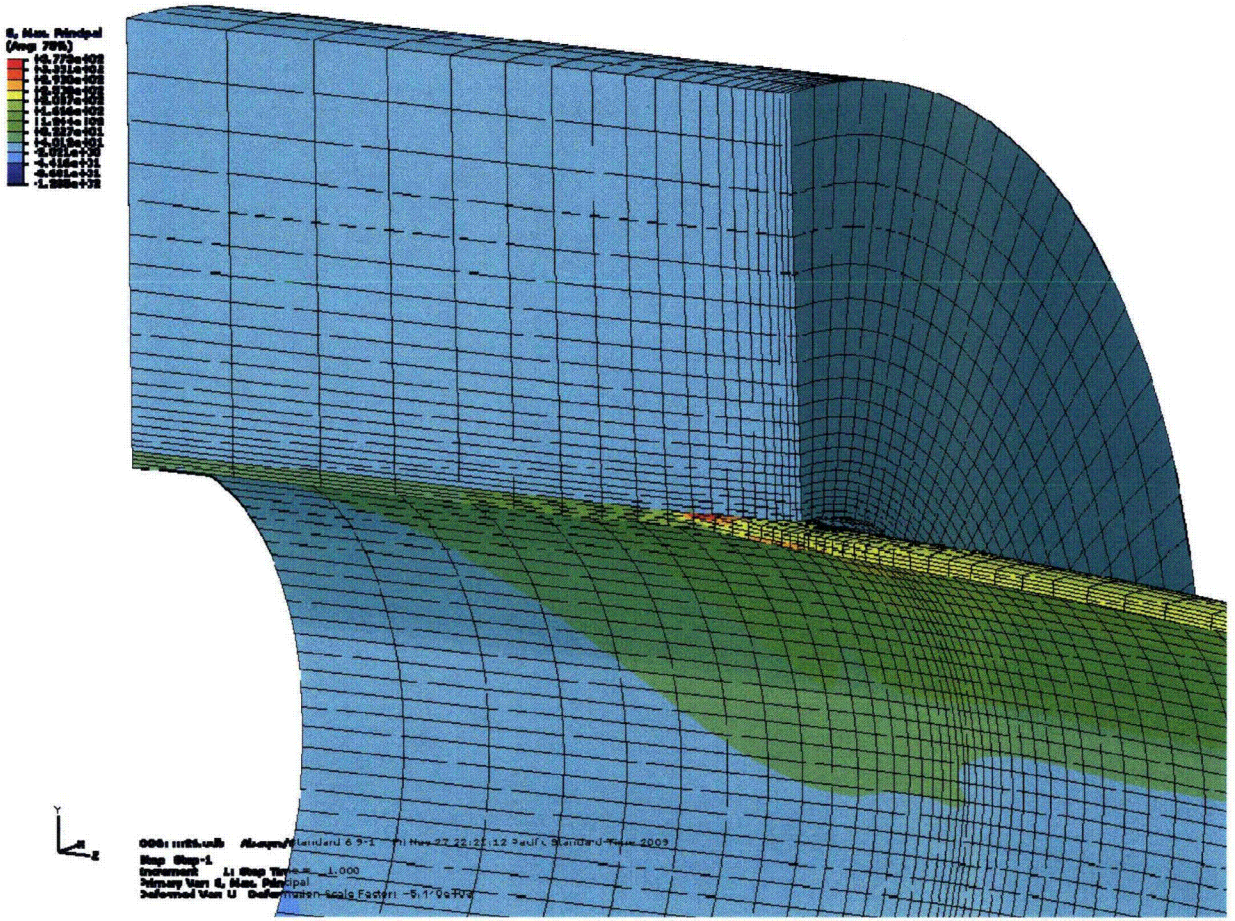
Principal Stress Steel and Concrete



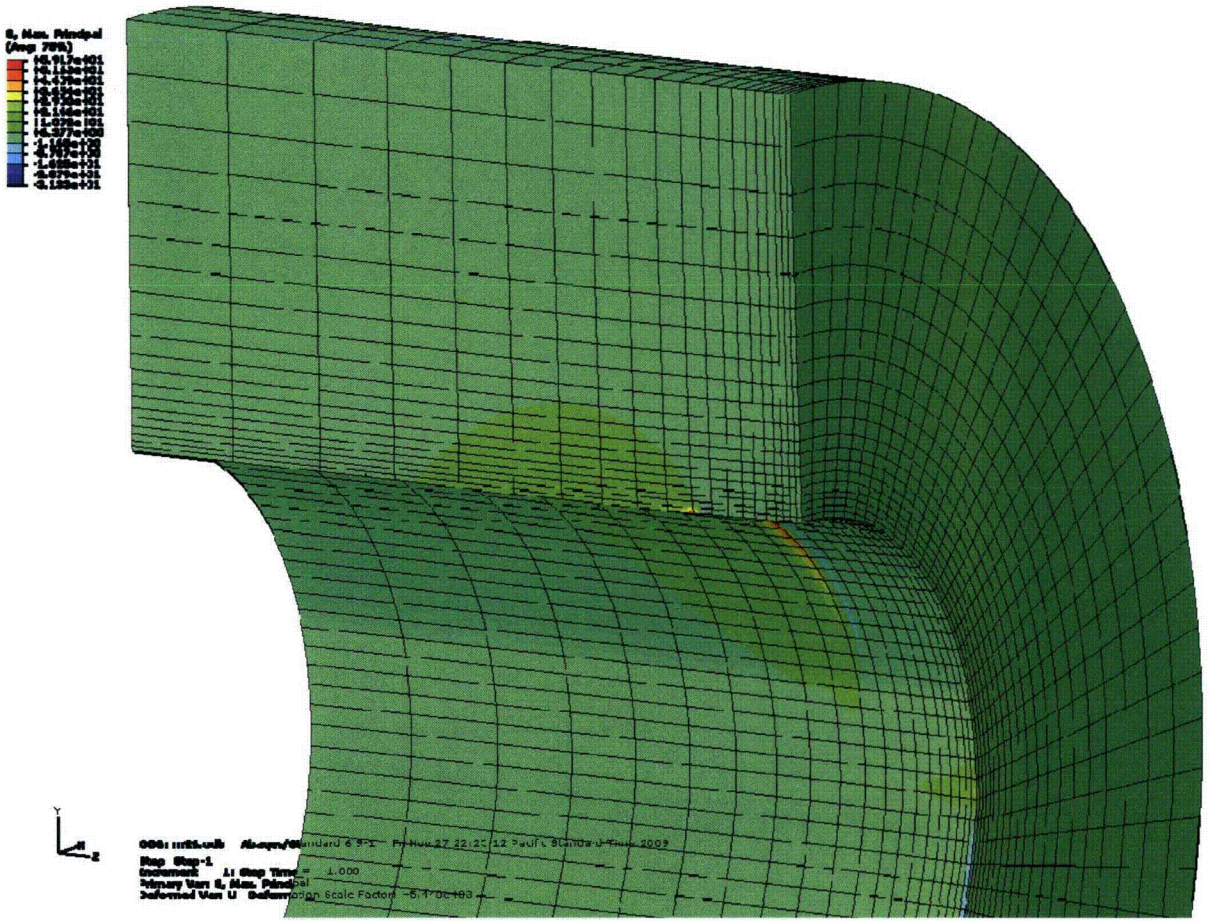
Mesh



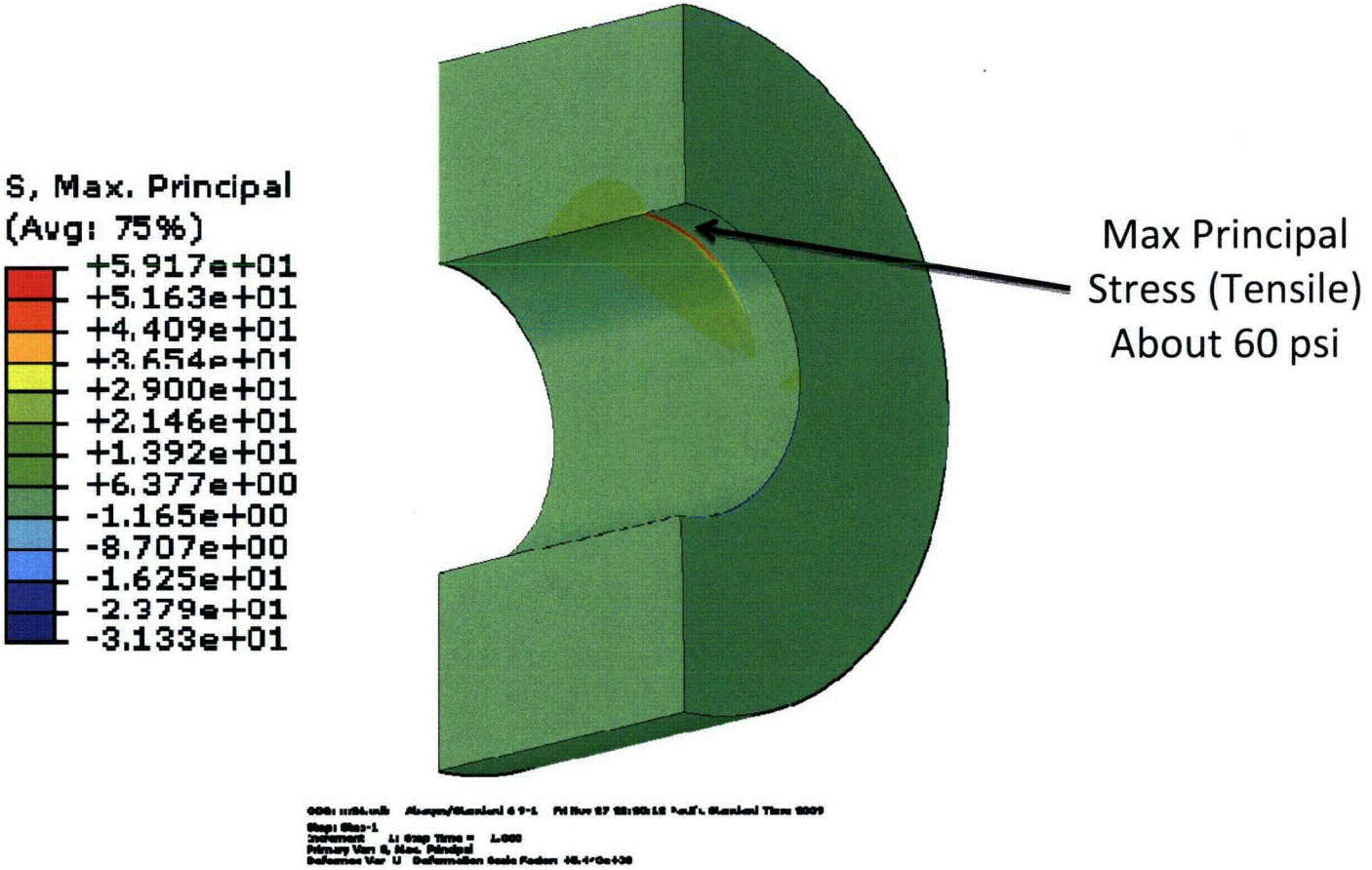
Mesh Detail



Concrete Only



Concrete Max Principal Stress

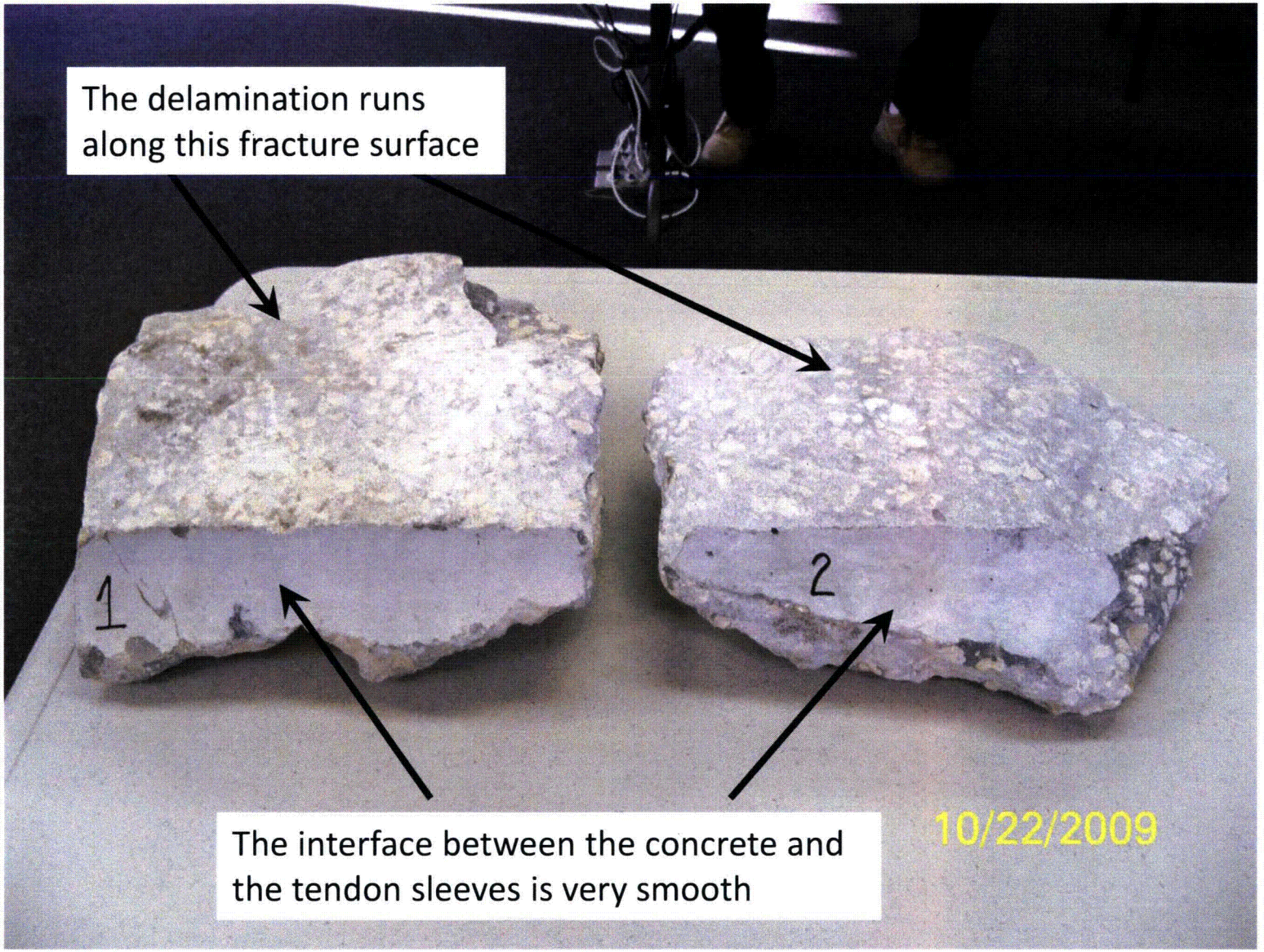


Stress Summary with 2 inch Separation

- Maximum Principal Stress in Concrete Wall
  - Less than 60 psi Tensile (down from 160 without separation)

Large pieces of concrete were removed during the hydro-blasting demolition project.

It can be seen that the interface of the concrete with the rigid tendon sleeves is very smooth.


The delamination runs along this fracture surface
1
2
The interface between the concrete and the tendon sleeves is very smooth
10/22/2009