Public Service

Public Service
Company of Colorado

16805 WCR 19 1/2, Platteville, Colorado 80651

April 19, 1990
Fort St. Vrain
Unit No. 1
P-90103

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Docket No. 50-267

SUBJECT: Licensee Event Report 89-015-01, Final Report

REFERENCE: Facility Operating License No. DPR-34

Gentlemen:

Enclosed, please find a copy of Licensee Event Report No. 50-267/89-015-01, Final, submitted per the requirements of 10 CFR 50.73(a)(2)(i)(A) and 50.73(a)(2)(v)(A).

If you have any questions, please contact Mr. M. H. Holmes at (303) 480-6960.

Sincerely,

C. H. Fuller
Manager, Nuclear Production
and Station Manager

CHF/lmb

Enclosure

cc: Regional Administrator, Region IV
ATTN: Mr. J. B. Baird
Technical Assistant
Division of Reactor Projects

Mr. R. E. Farrell
Senior Resident Inspector, FSV

IE22
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U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES 8/31/88

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Fort St. Vrain, Unit No. 1	0 5 0 0 0 2 6 7	1 OF 1 1

TITLE (4): REGION 19 CONTROL ROD DRIVE FAILED TO FULLY INSERT ON SCRAM SIGNAL

EVENT DATE (5) Month	Day	Year	LER NUMBER (6) Year	Sequential Number	Revision Number	REPORT DATE (7) Month	Day	Year	OTHER FACILITIES INVOLVED (8) Facility Names	Docket Number(s)
0 8	1 8	8 9	8 9	– 0 1 5 –	0 1	0 4	1 9	9 0	N/A	0 5 0 0 0
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OPERATING MODE (9): N
POWER LEVEL (10): 0 7 9

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)

[ ] 20.402(b)	[ ] 20.405(c)	[ ] 50.73(a)(2)(iv)	[ ] 73.71(b)
[ ] 20.405(a)(1)(i)	[ ] 50.36(c)(1)	[X] 50.73(a)(2)(v)	[ ] 73.71(c)
[ ] 20.405(a)(1)(ii)	[ ] 50.36(c)(2)	[ ] 50.73(a)(2)(vii)	[ ] OTHER (Specify in Abstract below and in Text, NRC Form 366A)
[ ] 20.405(a)(1)(iii)	[X] 50.73(a)(2)(i)	[ ] 50.73(a)(2)(viii)(A)	
[ ] 20.405(a)(1)(iv)	[ ] 50.73(a)(2)(ii)	[ ] 50.73(a)(2)(viii)(B)	
[ ] 20.405(a)(1)(v)	[ ] 50.73(a)(2)(iii)	[ ] 50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER Area Code	
S. W. Chesnutt, Supervisor, Nuclear Licensing-Compliance	3 0 3	6 2 0 - 1 0 2 7

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS
X	A A	J C	6 0 6 3	Y					

SUPPLEMENTAL REPORT EXPECTED (14)

[ ] YES (If yes, complete EXPECTED SUBMISSION DATE) [X] NO

EXPECTED SUBMISSION DATE (15): Month | Day | Year

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

At 1820 hours on August 17, 1989, with the plant operating at approximately 79 percent power and 256 MWe, the region 19 control rod pair failed to properly insert during the weekly partial scram test (SR 4.1.1.B.1/2-W). This insertion failure was immediately indicated by actuation of a "slack cable" alarm for region 19.

At approximately 1900 hours the region 19 rod pair was retested but again failed | to properly insert. At 0430 hours on August 18, 1989, following extensive troubleshooting efforts and analysis of region 19 back-EMF data, the region 19 control rod pair was declared immovable and an orderly plant shutdown was | initiated. Plant shutdown was complete at 1555 hours on August 18.

| Through visual inspection of the region 19 CRD, it was determined that a failed clevis bolt head became lodged between one of the control rod absorber strings and its guide tube, thereby preventing rod insertion. GA International Services | Corp. performed a metallurgical analysis on the failed bolt head and concluded | that the failure resulted from a combination of tension, shear, and bending load | applied to the bolt locking ring groove. No defects were observed in the failed | bolt. These findings are consistent with PSC's initial analysis.

| PSC has decided to permanently shutdown and defuel FSV. To date, twelve of the | thirty seven reactor fuel regions have been defueled. No additional clevis bolt | failures have been identified.

BACKGROUND:

Interim Technical Specification LCO 3.1.1 requires that "all control rod pairs not fully inserted shall be operable with a scram time of less than or equal to 152 seconds". Interim LCO 3.1.1 is applicable during startup, low power, and power operation. Control rod operability in regard to this 152 second scram time criteria is demonstrated at least once per 7 days during reactor operation by performing a partial scram test of at least 10 inches on all partially inserted and fully withdrawn control rods, with the exception of the regulating rod. During this weekly partial scram test the change in rod position (inches) and the time required to travel that distance are utilized to extrapolate the time required for complete insertion of that rod from the fully withdrawn position.

Back Electro-Motive Force (EMF) data is normally collected during the weekly partial scram test, and control rod drive (CRD) motor wattage data is collected during the subsequent withdrawal of the rod to its initial position. Use of back-EMF and CRD motor wattage data provides a systematic process by which CRD performance can be monitored.

EVENT DESCRIPTION:

On August 17, 1989, the reactor was operating at approximately 79 percent power with both primary and secondary coolant loops (AB)* in normal operation. At approximately 1700 hours on August 17, plant personnel began performing the weekly control rod (AA)* partial scram test (SR 4.1.1.B.1/2-W). This surveillance test is performed on all of the partially inserted and fully withdrawn control rod pairs at least once per 7 days during reactor operation to verify control rod pair extrapolated scram time is less than or equal to 152 seconds.

Twenty rod pairs had been successfully tested prior to testing the region 19 rod pair. At approximately 1812 hours, with the region 19 rod pair approximately 43 inches withdrawn, a partial scram test was performed on region 19. Upon manually scramming the rod pair, the region 19 "slack cable" alarm actuated in the control room. Reactor operators set the brake on the region 19 CRD to halt any further rod movement. At 1837 hours, after receiving permission from the shift supervisor, the region 19 rod pair was withdrawn back to its initial position (43 inches) and the region 19 "slack cable" alarm cleared. Operators then proceeded to complete partial scram testing of the remaining sixteen rod pairs. At approximately 2000 hours on August 17, 1989, all rod pairs had been scram tested, thirty six rod pairs successfully and one rod pair (region 19) unsuccessfully.

* Energy Industry Identification System (EIIS) Codes

At 2045 hours, plant management personnel were notified and informed of the region 19 slack cable problem. At 2130 hours, technical personnel were called out to troubleshoot the region 19 CRD. At 2200 hours, NRC Region IV was contacted and informed of the event and ongoing troubleshooting efforts. For the next several hours, tests were conducted to verify the actuation of the slack cable switches and to measure shim motor wattage for rod withdrawal movements. In all cases, the slack cable indication was received at the beginning of rod insertion movements (motor driven or scrammed) and cleared on subsequent rod withdrawal movements. Wattage data on extended withdrawal movements showed the shim motor was drawing power in periodic surges.

At 0430 hours on August 18, 1989, after extensive analysis and troubleshooting efforts had verified that the rod was not inserting, the region 19 rod pair was declared immovable and an orderly plant shutdown was initiated from approximately 79 percent reactor power. At 1555 hours, a manual scram was inserted from 2 percent reactor power, per procedure, thereby completing the shutdown action.

Following completion of the reactor shutdown, T-Test 434 was written in the attempt to fully insert the rod pair, where its full worth would be utilized in the core. The test involved withdrawing the rod in ten inch increments, monitoring the shim motor wattage during each pull, and then driving the rod pair to full insertion in ten inch increments. After four withdrawal movements and one insertion movement, the rod pair stopped moving when power was applied to the shim motor. At this point, the shim motor was presumed to be burned out, and plans to remove the control rod drive from the core to the Hot Service Facility (HSF) for further inspection were initiated.

On August 25, 1989, at approximately 2300 hours, the region 19 CRD was removed from the core and placed in the HSF for inspection. A spare CRD was then installed into region 19, demonstrated operable, and fully inserted into the core.

CAUSE:

With the region 19 CRD in the HSF, the immovable control rod absorber string (only one rod of the region 19 rod pair was immovable) was removed from its guide tube. During the removal process, a small metal object was dislodged from between the guide tube and control rod absorber string. Examination of the removed absorber string identified that the top two absorber canisters displayed a vertical row of indentations. The guide tube of the immovable rod also displayed vertical abrasions that correlated to those on the absorber canisters. Further inspection identified that the clevis bolt that connects the absorber canister string to the CRD cable (see Figure 1) had failed on both region 19 control rod absorber strings and the bolt heads had become detached from the clevis bolt shafts.

* U.S.GPO 1986-0-624-538/455

One of these failed clevis bolt heads became lodged between the absorber canisters and the guide tube wall, causing the rod to bind and become immovable. The other failed clevis bolt head on the absorber string has not been accounted for but had no apparent effect on the ability to insert the other rod of the pair.

| Possible Causes Of Clevis Bolt Failure:

| The initial region 19 clevis bolt failure analysis identified four possible failure mechanisms:

- Failure due to material defects
- Shear failure due to impact with the guide tube during withdrawal
- Tensile failure due to over-torquing the clevis bolts
- Tensile failure due to differential thermal expansion effects

| Failure Due To Material Defects:

PSC performed a metallographic examination of a randomly selected Inconel clevis bolt from stock. No observable defects or irregularities were identified during this examination. GA International Services Corp. (GA) also performed a visual examination of the failed region 19 clevis bolt and found no observable defects or irregularities. It is considered highly unlikely that two clevis bolts on the same control rod pair would contain material defects. These considerations essentially eliminate the likelihood that the failure was caused by material defects.

| Failure Due To Guide Tube Impact:

Similarly, the likelihood that the failure was caused by shear loading on the bolt head from guide tube interaction is considered remote. The degree of mis-alignment required to permit the interaction is substantial and would most likely be detectable in surveillances performed on the control rod drive. In fact, the starting acceleration of the region 19 CRD, as calculated from back-EMF data, was superior to all but one other rod in core, which implies the interaction between the absorber string and control rod channel was minimal. Perhaps the strongest argument against guide tube impact being the failure mode is that following the shear failure, for the bolt head to become lodged between the absorber canister and guide tube wall, it would have to land directly on the top of the uppermost absorber canister and balance there until the top absorber canister entered the guide tube, then fall into the clearance between the canister and the guide tube wall.

Tensile Failure Due To Torquing:

During the control rod drive refurbishment program in 1985, the absorber strings were removed from the CRDs in order to change out the cables and simplify CRD handling outside of core. After the drives were refurbished, just prior to returning to core, the absorber strings were reattached to the CRD cables by inserting the ball end into the clevis and installing the clevis bolt. The bolt was then torqued into the split locking nut which is attached to one prong of the clevis. This operation was performed remotely, because of the high radiological activation of the control rods. The actual torquing of the clevis bolt was accomplished behind a barrier with a two foot drive shaft and a hand crank.

The actual torque applied to the clevis bolt in re-attaching the control rods to the cables was not controlled. The original version of the control rod refurbishment procedure specified a maximum torque for the clevis bolt installation. In many instances, however, this maximum value was found to be insufficient to fully seat the bolt head against the clevis prong, due to clevis deformations causing mis-alignment and the resistance of the split locking nut. The torque requirement in the procedure was subsequently modified to call for a "snug-tight" fit. The Change Notice documenting the design changes to the clevis bolt indicated that torque applied to the clevis bolts was negligible.

It is not possible to determine the amount of torque actually applied to the clevis bolts. Estimates from personnel involved in the work range from 50 to 100 ft-lbs, which could easily be accomplished with the tools used and the general arrangement of the worker and components. A test was conducted using a stock clevis and bolt to determine the torque required to fully seat the bolt. Test results indicate that a minimum of 8.3 ft-lbs is required to overcome split locking nut resistance and a total of 10 ft-lbs is required to fully seat the bolt. Since a "snug-tight" fit implies the total applied torque should exceed the nominal driving torque, it is reasonable to assume that a minimum of 15 to 20 ft-lbs was applied to the clevis bolts. The maximum torque applied to the clevis bolts is limited by thread shear in the locking nut.

The effects of pre-loading the clevis bolts were also analyzed. The part of the bolt most susceptible to tensile failure is the locking ring groove (see Figure 1) cut into the bolt shank. This corresponds to the location of the fracture observed in both failed clevis bolts. The torquing of the clevis bolts does not entirely account for the failures observed, since the heads would have sheared when the load was initially applied. Residual tensile and shear stresses from the initial torquing would remain within the bolt and combine with other stresses which could eventually have caused the failures observed.

*U.S.GPO:1986-0-624-538/455

Tensile Failure Due To Thermal Effects:

During the CRD refurbishment program in 1985, approximately 18 control rod pairs (including the region 19 rod pair) were refurbished with Inconel X-750 clevis bolts. The remaining rods were left with the original A-286 high strength alloy steel clevis bolts due to material availability. The clevis prong itself is made of 321 stainless steel while the support ball end is made of Inconel 625 (see Figure 1).

| The temperature that the clevis assembly was exposed to during reactor operation is influenced primarily by the position of the rods. In the fully withdrawn position, the purge flow through the upper CRD housing cools the clevis assembly to approximately 200 to 300 degrees F. As the control rod is inserted further into core, the cooling effects of the purge flow are reduced and radiant heat from the core increases the operating temperature. In the fully inserted position, the clevis is below the upper plenum in a control rod channel, in which only about 4% of the total cooling flow passes. Temperature estimates in the control rod channels range from 740 degrees F at the upper plenum to 930 degrees F at the channel exit. Based on these numbers, the temperature at the clevis of a fully inserted rod in core at 80 percent power is estimated to be approximately 800 degrees F.

The thermal expansion effects of the entire clevis assembly were analyzed. It has been determined that if the gap between the clevis prong wall and the ball end bearing (see Figure 1) were completely closed by preloading during refurbishment, the differential expansion between the stainless steel clevis prong and the Inconel X-750 clevis bolt during normal reactor core thermal cycling would cause significant tensile stresses to develop within the clevis bolt. The tensile stress caused by differential expansion would most adversely affect the bolt cross-section where the locking ring groove is
| machined. The magnitude of the thermally induced stress in itself is not sufficient to cause tensile failure independent of other mechanisms. However, thermal differential expansion stresses, unlike other thermal expansion stresses, are not self-equilibrating, and as such, they add to the tensile stress state in the bolt, and are at a maximum at the location of the fractures observed.

| Results Of GA Bolt Failure Analysis:

| PSC retrieved the clevis bolt head from the HSF and sent it to GA for failure analysis.

| GA's analysis of the failed clevis bolt focused on three issues:

- Visual examination of the bolt in GA's hot cell facility,
- Verification that the bolt was manufactured according to GA drawing specifications,
- Evaluation of bolt tensile stresses resulting from differential thermal expansion between the Inconel bolt and the stainless steel clevis prong.

| Analysis results concluded that the region 19 clevis bolt failed in a low ductility manner from what appeared to be a combination of tensile and bending loads. The failed bolt's material properties satisfied all requirements of the specification (i.e., ASM 5670) identified in GA drawings. No bolt defects were identified. And finally, it was concluded that the differential thermal expansion between the Inconel bolt and the stainless steel clevis prong, in conjunction with a normal bolt preload stress, could not account for the clevis bolt failure. Therefore, these findings support PSC's initial analysis conclusion that the failures were the result of excessive bolt preload due to over-torquing in combination with differential thermal expansion stresses that developed within the bolt during reactor power operation.

SAFETY ANALYSIS:

Completion of the reactor shutdown at 1555 hours on August 18, 1989, in accordance with the requirements of interim Technical Specification LCO 3.1.1 is being reported herein in accordance with 10 CFR 50.73(a)(2)(i)(A).

The generic implications of this clevis bolt failure problem constitute a condition that alone could have prevented fulfillment of the reactor scram safety function and is being reported herein in accordance with the requirements of 10 CFR 50.73(a)(2)(v)(A).

To ensure control rod operability and early detection of CRD anomalies, scram capability and performance were monitored on a weekly basis during reactor operation. It was during this weekly scram test on August 17, 1989 that the region 19 rod insertion problem was discovered. This same surveillance was performed on August 10, 1989, during which all 37 rod pairs were demonstrated to freely insert into the core with a scram time less than or equal to 152 seconds (including the region 19 rod pair). For more than one control rod pair to have been inoperable during this event, multiple clevis bolt failures that resulted in binding of the rod inside the guide tube would have had to occur during the seven day period since the last weekly partial scram surveillance was performed (i.e., August 10). The likelihood that such a condition would develop is considered remote.

Both Inconel clevis bolts on the region 19 control rod pair failed, but resulted in only one of the rods becoming jammed and immovable. The other rod of the pair was not affected and remained insertable. This suggests that a clevis bolt failure may or may not affect control rod insertion capability. In addition, at the time of the event twenty one of the thirty seven total rod pairs had high strength steel clevis bolts. The steel bolts are less likely to develop excessive tensile forces resulting in failure because there are no adverse effects from differential thermal expansion, and the cross sectional area of the bolt at the locking ring groove is slightly larger than the comparable area in the Inconel clevis bolt. Also, the failure of a steel bolt is less likely to jam a control rod because the fractured head is small enough to drop through the 1/2 inch diametrical clearance between an absorber canister and the guide tube or control rod channel wall.

It should be noted that had multiple control rod failures occurred, the reserve shutdown system (RSD) was available to ensure adequate reactor shutdown capability. The RSD system is comprised of thirty seven hoppers, each containing boronated graphite balls. The hoppers are integrated within the control rod drive assemblies located in each of the 37 core regions. The boronated graphite absorber material is contained in the hopper by means of a rupture disc. The absorber material can be released from each hopper by pressurizing the hoppers from a source of high pressure gas, causing the rupture discs to burst and release the absorber material into the core. The RSD system functions independent of the control rod drive system and is unaffected by any rod insertion failures. Per FSAR Section 3.8.3.1, "sufficient negative reactivity control is provided by the operation of all 37 hopper systems to shut the reactor down to refueling temperature from any reactor operating condition without movement of the controls rods. This condition can be met with one reserve shutdown hopper inoperative." On August 17, 1989 however, the RSD system was fully operational.

| On August 29, 1989, Public Service Company announced that Fort St. Vrain was permanently shutdown and that preparations were underway to begin the process of defueling the reactor. To date, the fuel elements from twelve of the thirty seven reactor fuel regions have been removed from the core and placed in the fuel storage wells. These twelve regions have been refilled with defueling elements composed of graphite and containing boronated graphite poison pins (but no fuel) for reactivity control. During the defueling of these first twelve regions, all control rod pairs in fueled regions have remained fully inserted (with the exception of control rod pairs being permanently removed from the core and rod pairs temporarily withdrawn for shutdown margin verification) and no additional clevis bolt failures or rod withdrawal/insertion difficulties have been identified. Shutdown margin verification during the remainder of the defueling process is expected to be accomplished using the control rod pairs of core regions 4 and 15. Both of these rod pairs contain high strength steel clevis bolts.

Based on the above analysis, it is concluded that the generic failure potential of the control rod clevis bolts did not pose a credible threat to the ability to | safely shutdown the reactor, nor does it pose a threat to safe reactor | defueling.

CORRECTIVE ACTION:

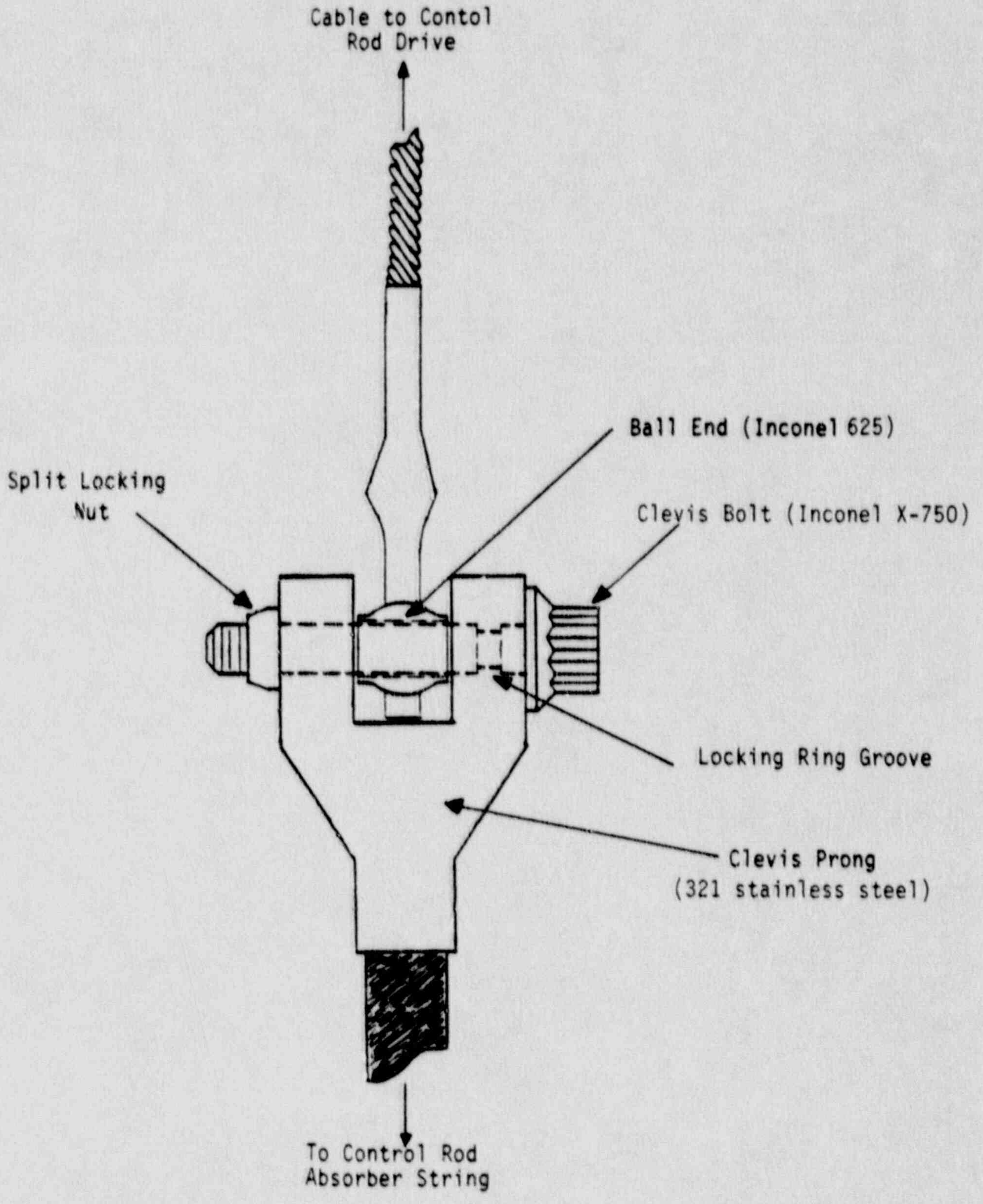
1. Upon declaring the region 19 control rod pair inoperable, an orderly reactor shutdown was initiated in accordance with the requirements of interim Technical Specification LCO 3.1.1.

2. The region 19 CRD was removed from the reactor core and replaced with an operable spare CRD.

| 3. The failed clevis bolt was analyzed by GA.

4. On August 29, 1989, Public Service Company announced that Fort St. Vrain will not be restarted, thus marking the end of the plant's operational phase. The reactor will remain subcritical throughout the defueling phase.

FIGURE 1.



U.S.GPO:1988-0-824-538/455

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