OPENAKA CORPORATION, INC.
565 OPENAKI ROAD
DENVILLE, NEW JERSEY 07834-9642
973-328-1540

March 8, 2000

Mr. James T. Van Rensselaer
American Pipe and Construction International
Apartado Aereo No. 90087
Santa Fe De Bogota, D.C. Columbia

RE: Internal Inspection, 4.7 Kilometers of 2.0 Meter Tibitó-Casablanca Pipeline
Openaka Project OP-9924E

Dear Mr. Van Rensselaer:

The following letter report presents the procedures utilized and the results of the internal inspection of 4.7 kilometers of the 2.0 meter diameter prestressed concrete embedded cylinder pipe Tibitó-Casablanca transmission main conducted by Openaka Corporation on February 8 through February 10.

Procedures

Internal inspection of the pipeline from Station K0-260 to Station K4+417 was made by visual examination and sounding of the concrete lining for hollows. Sounding of the lining for separation from the cylinder was performed using a length of 1.3 centimeter diameter galvanized steel pipe with welded-on threaded caps at both ends approximately 15 centimeters smaller in length than the inside pipe diameter. When sounding the wall with the metal pipe there is a distinct tonal difference between lining in compression and that which has separated from the steel cylinder. If loss of pipe compression due to prestress wire breakage has occurred it has been found to be detectable as a hollow, generally around the side quadrants.

The inspection was performed by two Engineers from Openaka Corporation, Robert E. Price, P.E. and Richard A. Lewis, P.E. They were assisted by Mr. Elemer Escrucería, an American Pipe and Construction International engineer and one laborer. Handheld flashlights were used for illumination. EAAB personnel performed the shutdown and dewatering of the pipeline and opened up the three entry ports for pipeline access. The EAAB also provided testing of the atmospheric conditions within portions of the pipeline in advance of the inspection crew. Since a wheel was not available for measuring distances to significant features joint counts were utilized.

The pipeline inspection was conducted in the sequence shown in Table I. Since two of the five entry ports within the 4.7 kilometers inspected were not opened, the actual distance covered

in the inspection was approximately 7.8 kilometers due to the need to backtrack in several cases.

**Table I**
**Internal Inspection Sequence**

| Date | Station | | Comments |
|---|---|---|---|
| | Begin | End | |
| February 8 | K1+291 | K0+808 | Inspection terminated due to high water near blow-off. Exited at K1+291. |
| | K1+291 | K0-260 | Inspection terminated at Valve #7. Exited at K1+291. |
| February 9 | K2+055 | K1+291 | |
| | K3+856 | K4+417 | Inspection terminated at Valve #9. Exited at K3+856. |
| February 10 | K2+055 | K3+856 | |

Results

Pipeline features and observed defects noted during the internal inspection are contained in Table II. In the absence of a laying schedule, the joint counts listed should be considered approximate and exact locations verified in the field as necessary.

**Table II**
**Internal Inspection Results**

| Station | Joint Count | Figure | Description/Observations |
|---|---|---|---|
| K0-206 | 118 from entry port at K1+291 | | 1.5 meter Valve #7. |
| | 117 from entry port at K1+291 | 1, 2 | 2 meter by 1.5 meter reducer. Severely cracked lining at west springline and above east springline. |
| | 116 from entry port at K1+291 | 3 | 2 meter steel special. Spalled lining on east side. |

**Table II (cont'd)**
**Internal Inspection Results**

| Station | Joint Count | Figure | Description/Observations |
|---|---|---|---|
| | 14 from entry port at K0+539 | 4, 5 | Spalled joint mortar and concrete lining 8 centimeters to 16 centimeters wide from 0.3 meter below the west springline, across the crown, to 0.6 meter below the east springline. |
| K0+539 | | | Unopened entry port. |
| | 25 from blow-off at K0+794± | 6, 7 | Spalled joint mortar and cracked concrete lining at the crown. Joint open approximately 2.5 centimeters at invert, zero at crown. |
| K0+794± | | | Blow-off. |
| | 15 from entry port at K1+291 | 8 | Missing joint mortar at the invert. |
| K1+291 | | | Entry port in pasture. |
| K1+597± | | | Air release valve. |
| | 18 from entry port at K2+055 | 9, 10 | Loose patch at joint from west to east springline across the invert. |
| K2+055 | | | Entry port by river. |
| | 29 from entry port at K2+055 | | Elbow up at bottom of slope. |
| | 40 from entry port at K2+055 | | Blow-off. Lining hollow at outlet saddle plate. |
| K2+952 | 128 from entry port at K2+055 | 11, 12 | Spalled joint mortar and lining patch across invert to just above both springlines at the north joint of the steel plate special with an entry port. The concrete lining is hollow. |
| K3+856 | | | Entry port at golf course. |
| | 43 to 44 from entry port at K3+856 | 13, 14, 15 | Failure repair consisting of steel short and steel closure. The concrete linings of both steel specials are cracked and hollow. |

**Table II (cont'd)**
**Internal Inspection Results**

| Station | Joint Count | Figure | Description/Observations |
|---|---|---|---|
| | 54 to 55 from entry port at K3+856 | | Air release valve. |
| K4+417 | 60 from entry port at K3+856 | | 1.5 meter Valve #9. |

Defects noted in the inspection were limited to local lining spalls at five joints, lining cracks in a repair section, and spalls and cracks in a reducer and steel plate special at a valve. Details are as follows:

2.0 Meter Steel Plate Special and 2.0 Meter by 1.5 Meter Reducer at Valve #7, K0-206

Cracking and spalling of the concrete lining of the steel plate special and reducer south of valve #7 at K0-290 was observed. There was a lining crack with some minor spalling at the west side of the reducer, Figure 1. Figure 2 is a photograph of the lining crack above the east springline. There was a large spall on the east side of the steel plate special, Figure 3.

Both fittings were noted to have hollow linings which are common in un-prestressed specials similar to steel pipes.

The large area of spalled concrete lining on the east side of the 2.0 meter steel plate special next to the reducer by Valve #7 at K0-290 should be repaired. The crack at the west side of the 2.0 meter by 1.5 meter reducer has some small spalled areas.

14th Joint North of Entry Port at K0+539

The 14th joint north of the entry port at K0+539 had spalled joint mortar and concrete lining. The distress starts about 0.3 meter below the west springline and extends across the crown to 0.6 meter below the east springline. Figure 4 is of the spalling above the east springline while Figure 5 shows above the west springline. No joint movement was associated with the spall which might have occurred during installation. Repair of the joint is recommended.

25th Joint North of Blow-Off at K0+794±

Figures 6 and 7 show the joint spall and cracked concrete lining above the east and west springlines, respectively, at the 25th joint north of the blow-off at K0+794±. There was a joint

opening of approximately 2.5 centimeters at the invert that narrows to zero at the crown, indicating that the damage might have resulted from settlement. The joint should be repaired.

15th Joint North of Entry Port at K1+291

Joint mortar was missing at the invert of the 15th joint north of the entry port at K1+291. Due to the presence of standing water at the joint, the lack of joint mortar is barely visible at the edge of the water in Figure 8. Re-pointing of the joint is recommended.

18th Joint North of the Entry Port at K2+055

An old lining patch was noted at the 18th joint north of the entry port at K2+055. The patching was loose from springline to springline across the invert. Figure 9 shows the joint below the west springline while Figure 10 is of east haunch and invert. Disruption of the lining patch might have occurred during pipe installation. Loose or spalled patching material should be removed and the joint repaired.

North Joint of Steel Plate Special with Entry Port at K2+952

The joint at the north end of the steel plate special with entry port at K2+952 exhibited spalling from the invert to just above the springlines. Figure 11 shows the spall below the west springline while Figure 12 is of the east springline. The lining of the steel plate special was hollow. Repair of the spalled joint mortar and lining is recommended.

Failure Repair 43 to 44 Joints South of the Entry Port at K3+856

The failure repair was located 43 to 44 joints south of the entry port at K3+856. A steel plate special short and steel closure were utilized to replace a failed section.. Linings of both specials was found to be cracked and hollow. Figures 13 shows cracking of the lining at the east side of the northern special while Figure 14 is of the crack on the west side.

Figure 15 is of a longitudinal crack in the lining of the southern steel plate special. In the photograph traces of carbonate can be seen intermittently along the crack.

Analysis and Discussion

Defects in a prestressed concrete embedded cylinder pipe that are indicative of incipient failure by burst include longitudinal core cracks with carbonate efflorescence and separation of the concrete liner from the steel cylinder resulting in hollows. Neither of these internal manifestations of prestressed concrete pipe distress were detected in the portion of the pipeline inspected either separately or in combination.

During the meeting at the conclusion of the inspection we were asked to give an explanation of our inspection techniques. These techniques are based on the fact that structural failure of a prestressed pipe occurs by breakage of the prestressing wires. When sufficient contiguous breaks occur and the pipe is in a condition of incipient failure the outer concrete core will crack and the residual compression in the steel cylinder is released. The expansion of the cylinder causes it to separate from the concrete core which can be effectively detected by a hollow sound. Since the internal pressure of prestressed concrete pipe acts upon the steel cylinder, cracking usually occurs in the lining when the cylinder expansion is sudden. In this case, if a sufficient pressure differential develops between the inside of the pipe and the cylinder, longitudinal cracks will occur in the concrete lining.

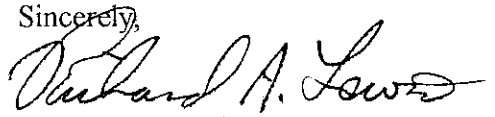
Visual inspection of the pipeline interior has proven effective in detecting longitudinal lining cracks that are indicative of prestress wire breakage as well as other forms of distress such as joint spalls and manufacturing anomalies. Longitudinal lining cracks accompanied by carbonate staining generally indicate a loss of prestress in the pipe wall. The presence of the carbonate deposits indicates that a crack is opening during pressure fluctuations.

Conclusion

In conclusion, the 4.7 kilometers of the 2 meter diameter Tibitó-Casablanca Pipeline inspected by Openaka Corporation shows no indication of structural distress. Several locations within the pipeline exhibited spalled joint mortar and concrete lining which should be repaired to restore corrosion protection to the underlying steel. While an internal inspection of this nature does not reveal the presence of exterior distress prior to the development of incipient burst conditions, the pipeline is serviceable under the recent operating conditions. Annual internal inspections are recommended as a routine maintenance procedure to detect distress that develops in the pipes in advance of failure conditions.

Should there be any questions on the inspection results or if we can be of further service please let us know.

Sincerely,



Richard A. Lewis, P.E.

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Figure 1. Cracked lining on the west side of the 2 meter by 1.5 meter reducer by valve #7, K0-260.

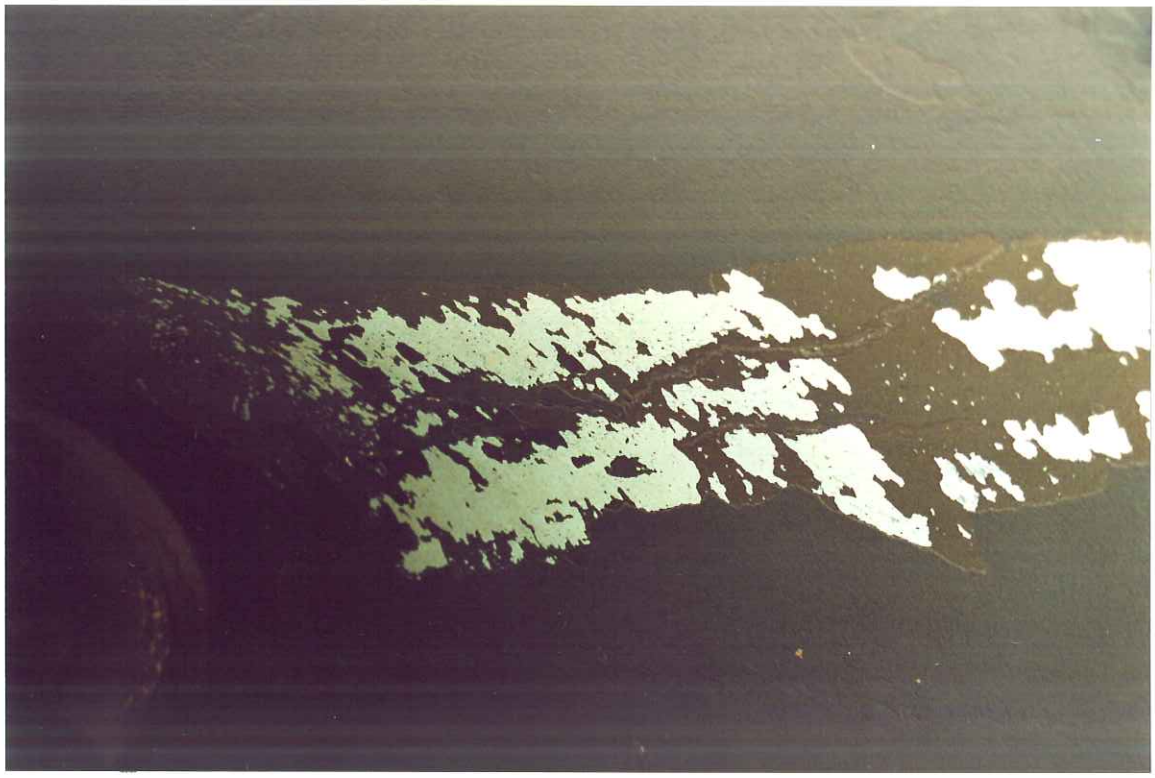

Figure 2. Cracked lining on the east side of the 2 meter by 1.5 meter reducer by valve #7, K0-260.

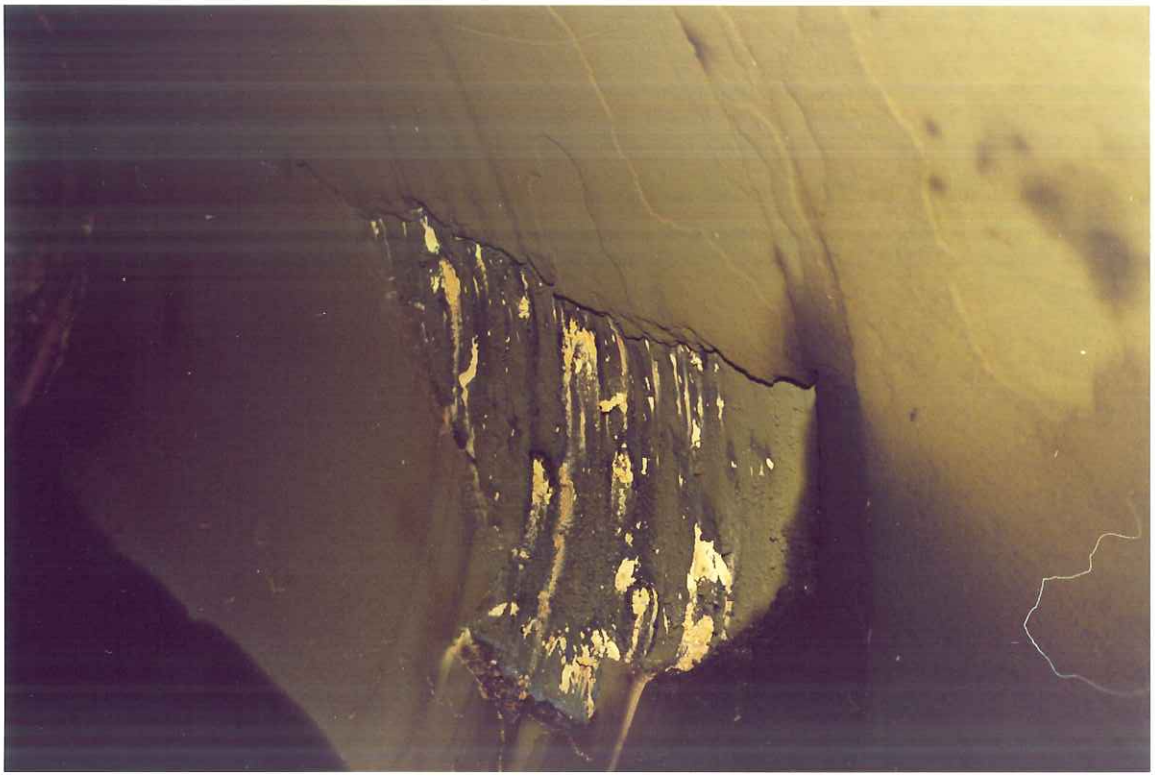

Figure 3. Spalled lining on the east side of the steel special next to the 2 meter by 1.5 meter reducer opposite valve #7, K0-260.

Figure 4. Spalled joint above the east springline of the 14th joint north of the entry port at K0+539.

Figure 5. Spalled joint above the west springline of the 14th joint north of the entry port at K0+539.

Figure 6. Spalled joint above the east springline of the 25th joint north of the blow-off at K0+794±.

Figure 7. Spalled joint above the west springline of the 25th joint north of the blow-off at K0+794±.

Figure 8. Joint mortar missing at the invert of the 15th joint north of the entry port at K1+291.

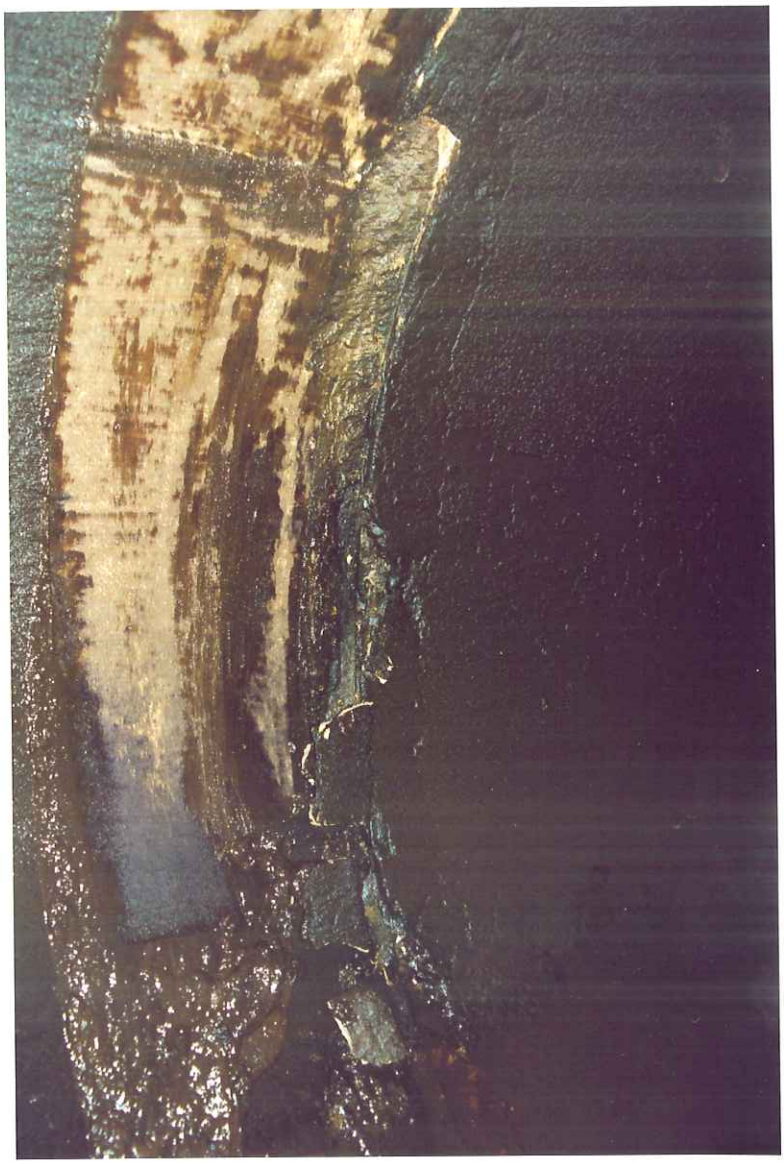

Figure 9. Loose patch below the west springline at the 18th joint north of the entry port at K2+055.

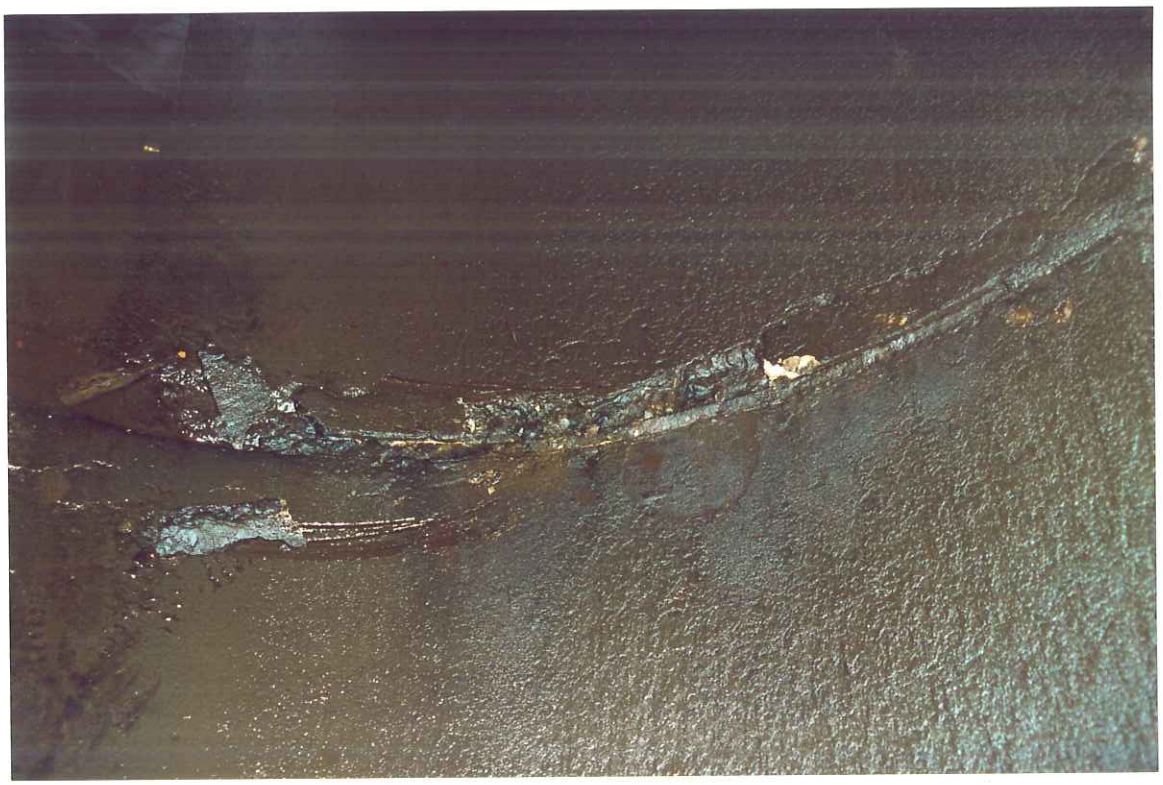

Figure 10. Loose patch below the east springline at the 18th joint north of the entry port at K2+055.

Figure 11. Spalled joint mortar and lining patch below the west springline at the north joint of the steel special with entry port at K2+952.

Figure 12. Spalled joint mortar and lining patch at the east springline at the north joint of the steel special with entry port at K2+952.

Figure 13. Cracked and hollow lining on the east side of the northern steel short at the failure location 43 to 44 joints south of the entry port at K3+856.

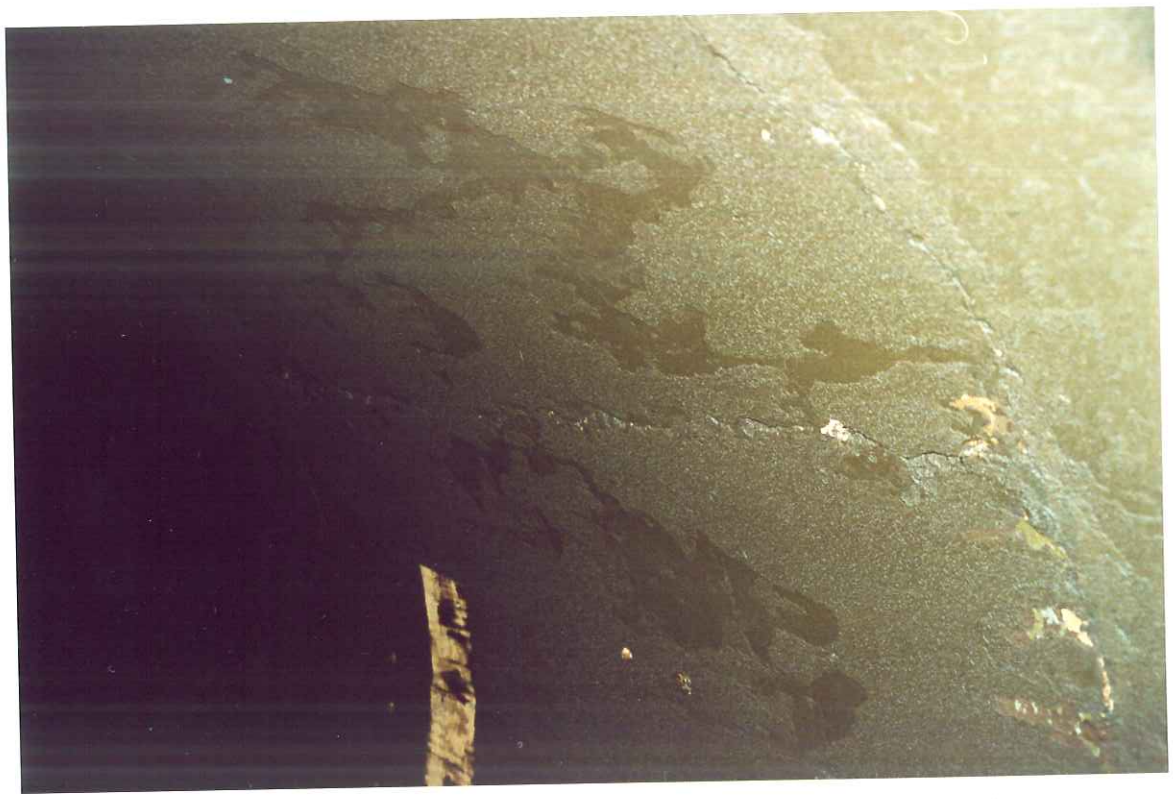

Figure 14. Cracked and hollow lining on the west side of the northern steel short at the failure location 43 to 44 joints south of the entry port at K3+856.

Figure 15. Cracked and hollow lining on the east side of the southern steel short at the failure location 43 to 44 joints south of the entry port at K3+856.