Stork Twin City Testing Corporation

PROJECT NUMBER: SOU263-01-15-91979 **DATE:** January 21, 2008

GRAIN STRUCTURE EXAMINATION

Sample Identification:

Cracked 2" diameter gas pipe section from PS07-002 Natural Gas Incident, Mitchell, South Dakota

Test Location:

Section W (evaluation for longitudinal seam weld) - Adjacent End B of full-length section
Section G (evaluation for groove adjacent fracture) – Through groove adjacent crack
Section NG (evaluation for no groove adjacent fracture) – Adjacent crack

Specimen Size:

Section W- Complete cross section of pipe diameter adjacent End B
Section G- Pie-shaped section through crack surface at groove location (Figures 5-6)
Section NG- Pie-shaped section through crack surface away from groove location (Figure 5)

Results:

Evaluation for Weld-

A transverse section was cut through a presumed longitudinal weld (Figure 1) in the 2" diameter gas pipe section. The transverse section was mounted in plastic, polished, etched in 10 % nital (10 % nitric acid in alcohol) and examined for grain structure. There was no grain deformation observed, but there was a significant variation in pearlitic grain structure (Figures 2-4).

In light of the fact that the pipe was installed sometime in the mid-1950s, these characteristics suggest that the 2" diameter gas pipe section was furnace butt-welded pipe. For example, a typical furnace butt-welded pipe of this vintage might have been made as "Open Hearth Class II" material according to API Specification 5L dated March,1955. A similar product, still produced currently, is continuous welded pipe, Grade A25, that is made in accord with API Specification 5L dated March 2004.

The grain structure examination was conducted on January 16, 2008 according to ASTM: E3-01.

Evaluation of Groove Adjacent Fracture-

Two pie-shaped sections were cut through the exposed crack surface (Figure 5). The G section was located at the groove (Figure 6) approximately midway between the ends of the crack (at location where crack opening was greatest). The NG section was located approximately 135º around the pipe circumference from the G section (Figure 5). The NG section was at one end of the crack, and no groove was present on the adjacent pipe outside diameter. Both sections were mounted in plastic, polished and etched in 10 % nital (10 % nitric acid in alcohol) to view the grain structures adjacent to the groove and the no groove locations. The groove is readily apparent in the macrophoto of the pipe wall thickness at and adjacent to the crack location (Figure 7).

The grain structures are shown in the photo collage (Figure 8) and the comparison location (Figure 9). The grain structures consisted of pearlite islands (dark) in a matrix of ferrite (light). The grain structure examination was conducted on January 16 and 17, 2008 according to ASTM: E3-01.

GRAIN STRUCTURE EXAMINATION (Cont.)

Test Equipment:

1. Olympus SZH stereomicroscope, ID Number 301-001, magnification range 3.75X-64X
2. Olympus PMG 3 metallurgical microscope, TCT Number MM300-001, calibrated 3-23-07

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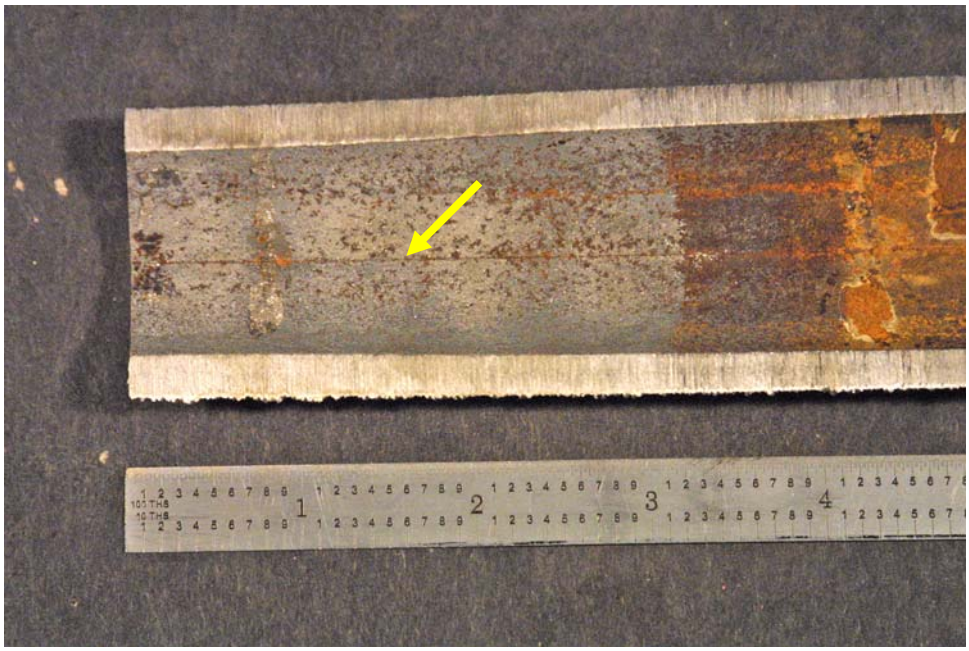

Figure 1: Presumed longitudinal weld seam on inside surface of gas pipe section (arrow).

Figure 2: Grain structure left of presumed weld seam consisting of pearlite islands (dark) in a matrix of ferrite (light). Magnification 70X

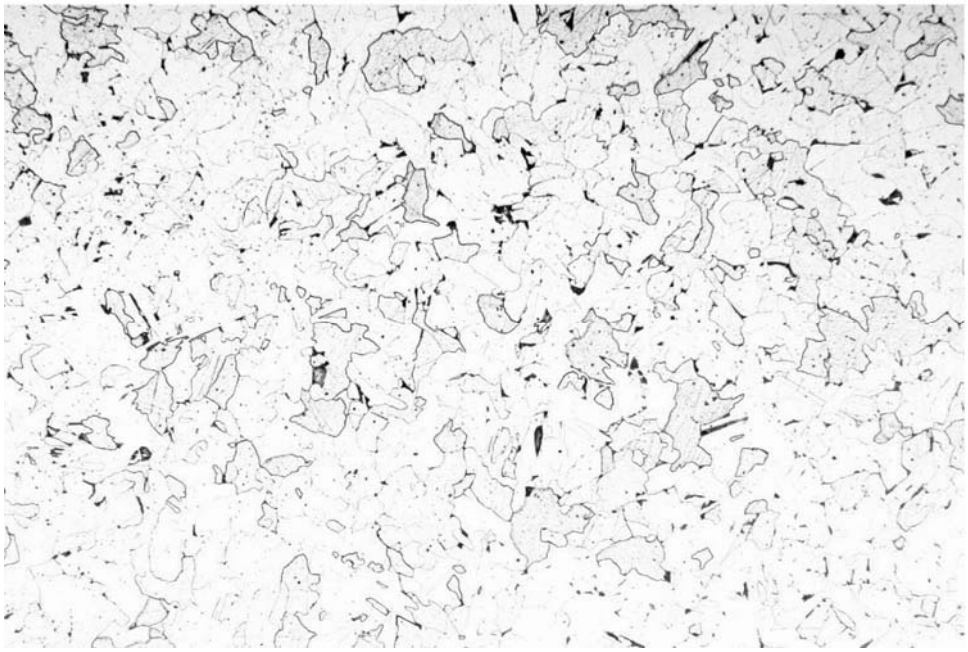

Figure 3: Grain structure at presumed weld seam consisting of pearlite islands (dark) in a matrix of ferrite (light). Note less pearlite present as compared to Figures 2 and 4. Magnification 70X

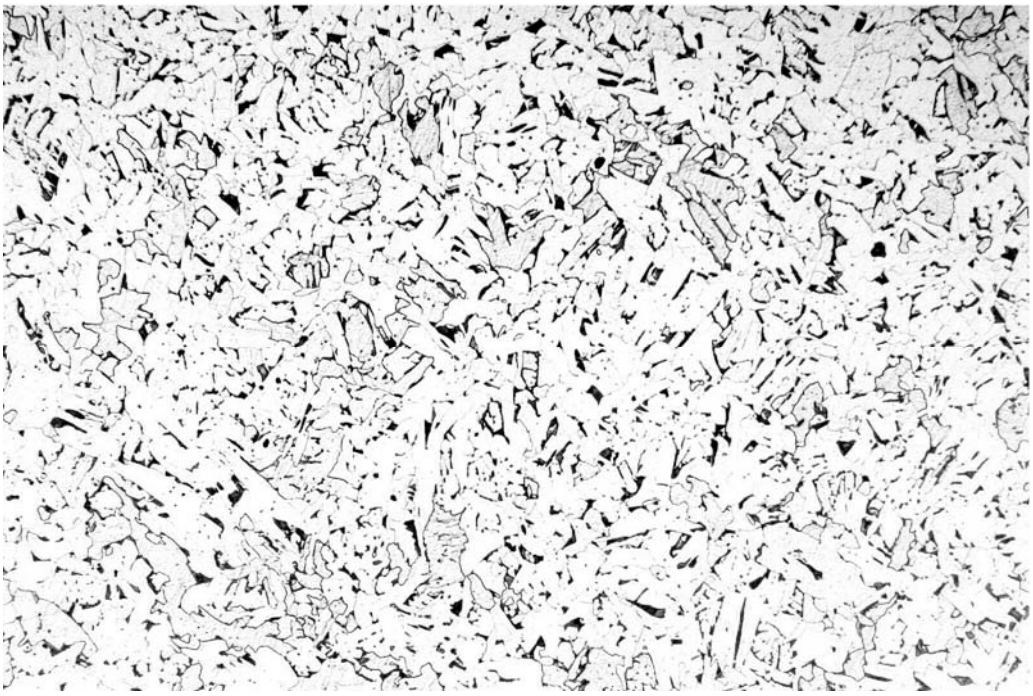

Figure 4: Grain structure right of presumed weld seam consisting of pearlite islands (dark) in a matrix of ferrite (light). Magnification 70X

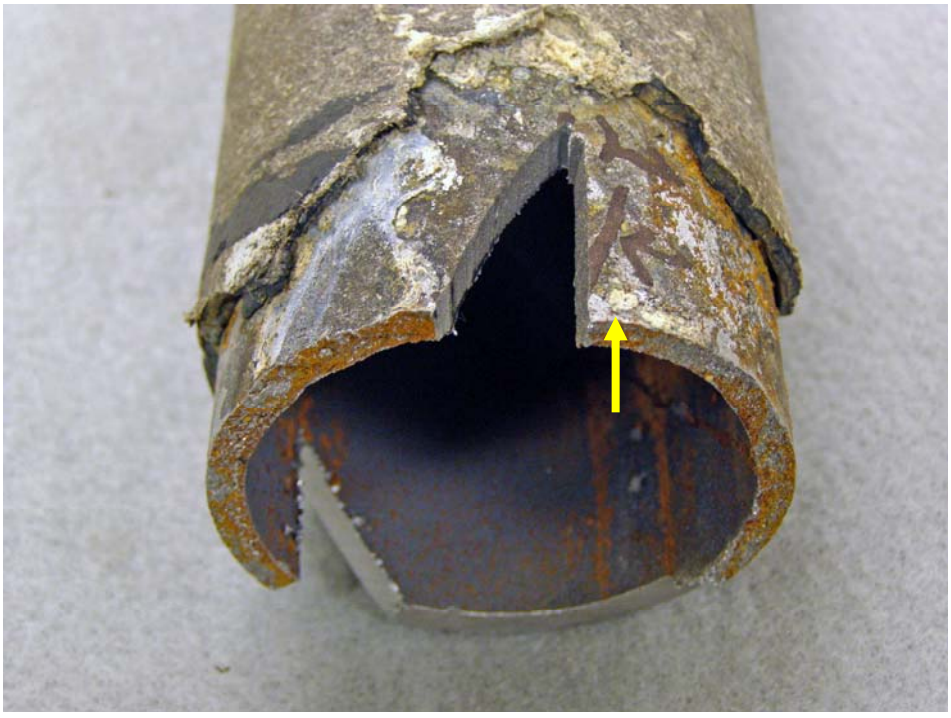

Figure 5: Failed end of the gas pipe section after separation of crack surfaces. Note the two pie-shaped sections cut and mounted for grain structure examination. Groove in pipe OD surface adjacent to crack is identified with arrow. Magnification 1.28X

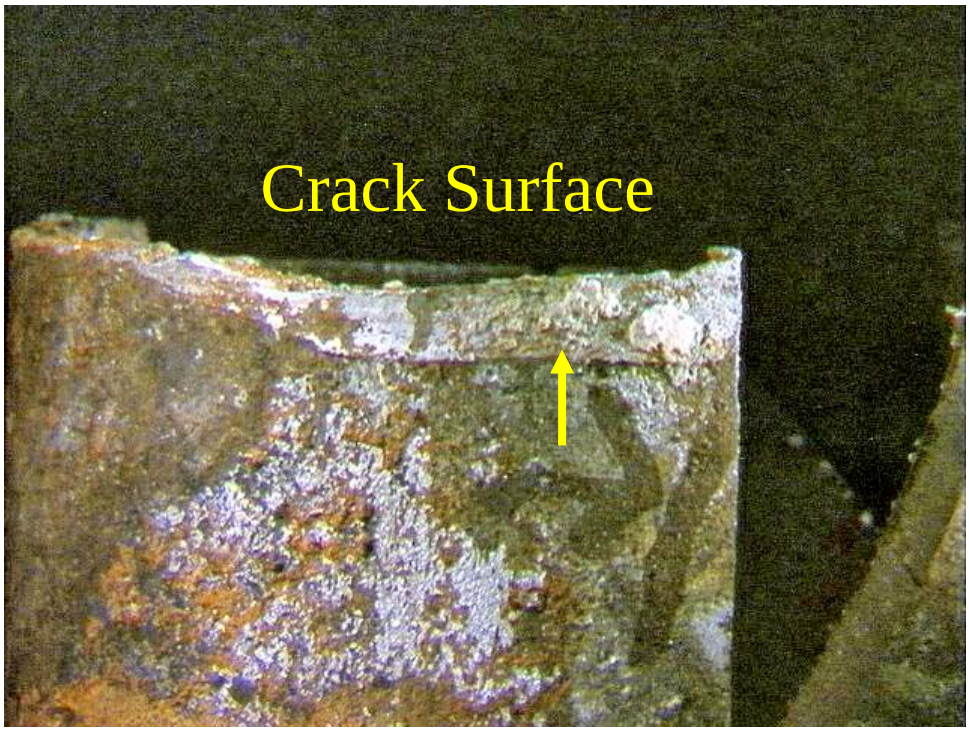

Figure 6: Close-up photo of the groove (arrow) adjacent to the crack surface at the point of maximum crack opening. Magnification 2.8X

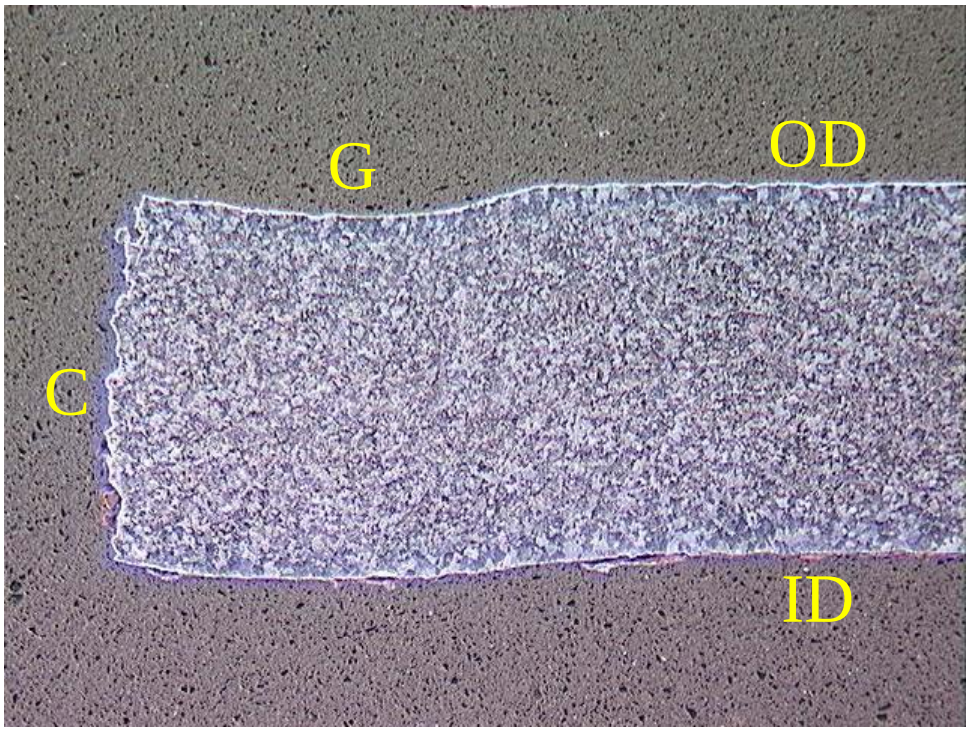

Figure 7: Cross section of pipe wall thickness through the groove (G) adjacent to the crack surface (C). The outside diameter (OD) and inside diameter (ID) of the pipe section are as shown. Mag. 11.8X

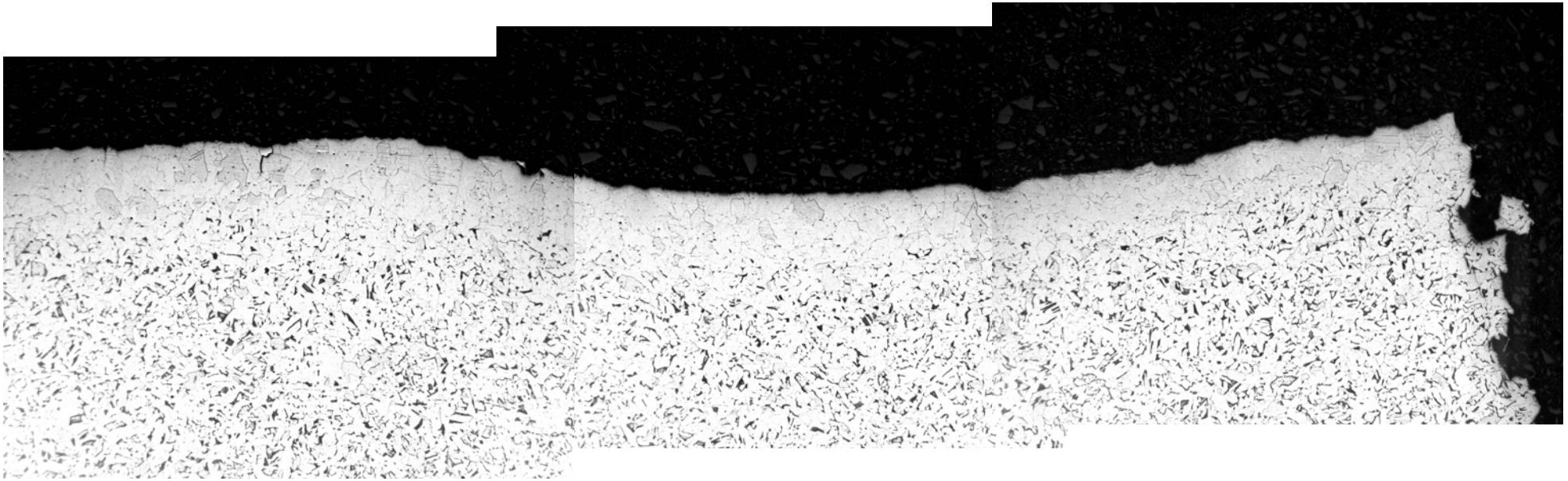

Figure 8: Composite photo of OD surface grain structure extending across the groove adjacent to the crack surface at right. Groove is readily apparent at top of photo. Grain structure consists of pearlite islands (dark) in a matrix of ferrite (light). Magnification 39.3X

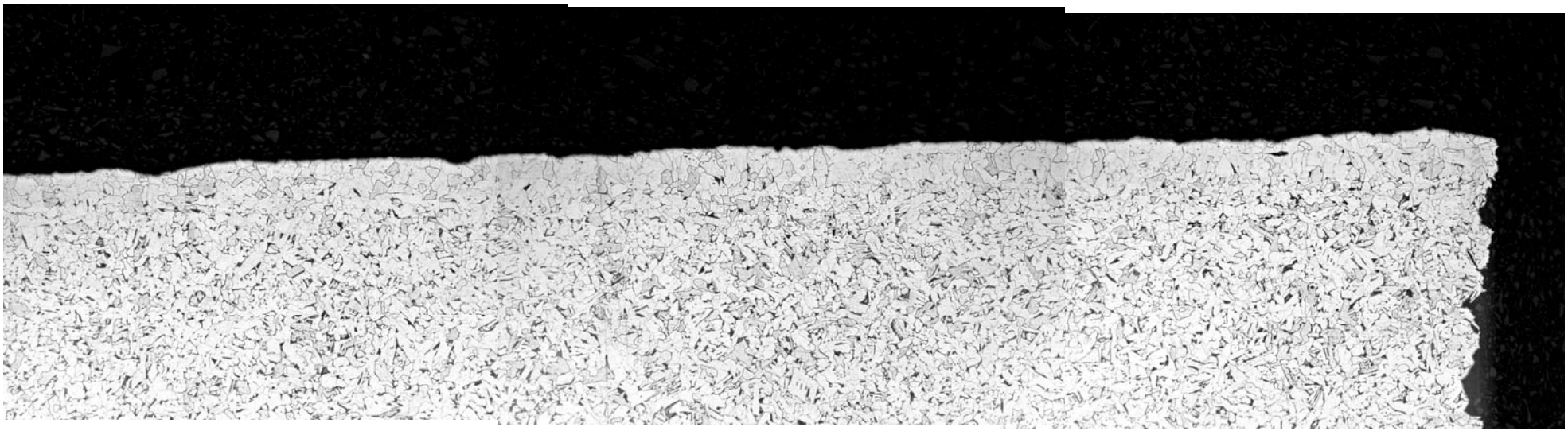

Figure 9: Composite photo of OD surface grain structure extending in from crack surface at right and at NG location (no groove). Grain structure consists of pearlite islands (dark) in a matrix of ferrite (light). Magnification 38.7X