DEPARTMENT OF TRANSPORTATION

Materials Transportation Bureau

[Docket No. 77–7W]

TRANS-ALASKA CRUDE OIL PIPELINE

Petition for Waiver of Girth Weld Defects

On May 24, 1977, the Alyeska Pipeline Service Company (Alyeska) delivered to the Department of Transportation (DOT) a request for a waiver of the DOT regulations governing the acceptability of liquid pipeline girth welds (49 CFR 195.226 and 49 CFR 195.228). More specifically, Alyeska seeks the waiver for all trans-Alaska crude oil pipeline girth welds containing irregularities interpreted as not complying with the DOT's requirements but which are within the parameters of the fracture mechanics decision curves contained in the DOT's November 26, 1976, decision on a similar but more limited request (41 FR 52933, December 2, 1976). Alyeska would have this new requested waiver apply to girth welds currently known to contain such irregularities as well as those that may be revealed by any current or future review or audit.

In the November 26 decision cited by Alyeska in support of its current request, the DOT, after careful consideration of the issues and the technical advice provided by its experts and consultants, determined that—

Fracture mechanics analysis is acceptable as a basis for granting exemptions from existing standards in appropriate circumstances, if such analysis produces a convincing and conservative estimate of structural integrity.

The specific criteria for applying this determination to the task of accepting or rejecting individual girth welds were set forth in the form of four decision curves in an appendix to the decision.

Originally Alyeska had requested a waiver for 612 of the approximately 30,000 field girth welds performed during the 1975 construction season. That number was reduced to 34 as repairs to the 1975 welds were completed during the construction season of 1976. In all, there are approximately 100,000 main line girth welds in the pipeline—30,000 field welds performed during each of the 1975 and 1976 construction seasons and 40,000 "double joint" shop welds performed at the pipe storage facilities in Fairbanks and Valdez joining two sections of pipe before transporting them to construction sites. Concerns about the quality of girth welds and the adequacy of the quality control system had prompted Alyeska to audit the radiographic records of the 1975 field girth welds during the winter of 1975–76. It was that audit which led to Alyeska's first girth weld waiver request.

with respect to the 34 unrepaired girth weld defects then known to exist, the DOT further determined that those having dimensions which fell below the decision curve for the type of defect concerned "do not constitute a risk of failure at those connecting points during the expected lifetime of the pipeline." The DOT found that 24 of the 34 welds were acceptable on the basis of fracture mechanics analysis. A waiver was granted for only three welds located under the Middle Fork of the Koyukuk River inasmuch as repair efforts on the other 21 were then well on their way to completion.

Shortly after the DOT's November 26, 1976, decision on that request, a new series of questions arose concerning the quality of girth welds that had been performed I the shops at Valdez and Fairbanks. These questions were the subject of hearings before the Subcommittee on Energy and Power of the House of Representatives' Committee on Interstate and Foreign Commerce on December 14, 1976.

DOT Girth Quality Sampling Program

Because of the concerns about the total girth weld population and because of the energy and environmental significance of the trans-Alaska crude oil pipeline, the DOT, as indicated during the hearings on December 14, 1976, undertook a statistical sample of the 1975 and 1976 field welds and double joint welds made in the Fairbanks and Valdez shops. A sample consisting of the radiographs for 500 randomly selected welds was chosen from each of the above three categories for a total sample size of 1500. Beginning in March 1977, the radiographs were interpreted by three DOT radiographic specialists. In order to minimize any dependent bias in the interpretation, each of the three radiographic specialists independently reviewed each of the radiographs from a listing of the approximately 100,000 girth welds against the DOT regulatory standard of acceptability as specified in 49 CFR 195.226 and .228. In each case where at least two specialists interpreted a radiograph as indicating an arc burn or a defect, related narrative records and documentation were examined and, two indepenednt [sic] radiographic experts reviewed the specialists' findings. The two radiographic experts, [1] are employees of Rockwell International Corporation under contract to the Energy Research and Development Administration (ERDA).

The ERDA experts, employing a technology used in dealing with the earlier waiver request, determined the depth and length of each defect they confirmed. A detailed report of the three DOT radiographic specialists' and the ERDA experts' findings and measurements has been made a pat of this docket. In summary, the results were as shown in Tables I and II.

TABLE I.—*Welds containing defects identified by DOT specialists*[2]

Type of defects	1975 welds	1976 welds	Shop welds	Total welds
Arc burns.....	78	28	21	127
Planar	15	6	5	26
Nonplanar.....	35	9	0	44
Total welds[3] ..	88	37	24	149

TABLE II.—*Welds containing defects identified by DOT specialists: Con-*

[1] Wayne D. Stump, manager of nondestructive testing, at the Rocky Flats Plant of Rockwell International (Prime U.S. ERDA contractor), where he has been employed for 25 years, holds a BS in Physics from the University of Denver and is a registered professional engineer in Colorado. Mr. Stump is a 25 year member and fellow of the American Society for Non-destructive Testing and has held several section offices in the Society. He is a certified ASNDT Level III in several test methods including radiography, and serves on the National Certification Panel for Level III personnel. He also holds membership in the American Society of Metals and the National Management Association.

John L. Summers, nondestructive testing area manager, at the Rocky Flats Plant, Rockwell International (Prime U.S. ERDA contractor), where he has been employed for the past 25 years, holds an associate degree of Science from Mascatine Junior College and has completed additional studies at the University of Colorado. Mr. Summers is a 22 year member and fellow of the American Society for Nondestructive Testing, having held several section offices in the Society. He is a certified ASNDT Level III in several test methods including radiography, and has served on the select Ad Hoc committee for Level III certification and is currently on the national Certification Panel for Level III personnel. He has been nominated as a National Director for ASNDT. Mr. Summers also holds membership in the American Society of Metals and the National Management Association and is a registered professional engineer in the State of California.

[2] This does not include indications of external undercuts. The depth of external undercuts which are often detectable by radiography cannot be evaluated by that technique. For this reason Alyeska, as is the standard practice in pipeline construction, employed visual external inspection to gage the depth of external undercuts and require repair when their dimensions exceeded DOT limits.

[3] The sums of the addends are less than the totals because some welds contain more than 1 class of defect.

firmed and measured by ERDA experts

Type of defects	1975 welds	1976 welds	Shop welds	Total welds
Arc burns	70	23	18	111
Planar	13	5	1	19
Nonplanar	31	9	0	40
Total welds[3] ..	72	28	18	118

FRACTURE MECHANICS ANALYSIS

As indicated in the DOT's November 26, 1976, decision on Alyeska's earlier waiver request, fracture mechanics is the study of the effects of defect size and orientation on the ability of a structure containing cracks to resist fracture. It permits quantitative estimation of the growth of cracks during the lifetime of the structure and is currently used in the design of aircraft and space vehicles, electrical power generating equipment including nuclear pressure vessels and ship cargo tanks used to carry liquefied natural gas. More recently it has been recognized by Lloyd's Register of Shipping (London, England) and Det Norshe Veratas (Oslo, Norway) to resolve critical questions relative to pipeline safety.

It was after a comprehensive review of all relevant material assembled during consideration of that earlier waiver request and following extensive consultation with its experts and consultants including a panel of distinguished public experts that the DOT concluded in November 1976, that fracture mechanics could serve as a basis for granting waivers from existing DOT standards without compromising pipeline integrity.

Using the measurements (length and depth) of each confirmed defect as determined by the ERDA experts and applying them to the fracture mechanics decision curves contained in the DOT's November 26, 1976, decision, the results are as shown in Table III.

TABLE III.—*Analysis of confirmed defects in 1,500 randomly selected girth welds based on November 26, 1977 decision curves*

Types of defects	Welds analyzed	Welds not acceptable			Welds found acceptable
		1975	1976	Shop	
Arc burns	111	3	0	0	108
Planar	19	0	0	0	19
Nonplnar	40	5	0	0	35
Total welds[3]	118	8	0	0	110

Although the question before the DOT on Alyeska's earlier waiver request concerned only a portion of the total main line girth welds, the conclusions reached and the accompanying decision curves developed for worst possible case situations are no less valid and applicable for the total pipeline. For this reason, I have decided to extend the applicability of that earlier decision to cover the entire 800-mile main line of the trans-Alaska crude oil pipeline and thereby grant the requested exemption from compliance with DOT welding standards (49 CFR 195.226 and 195.228).

WELDS NOT ACCEPTABLE UNDER NOVEMBER 26, 1976 FRACTURE MECHANICS DECISION CURVES

Being convinced of the adequacy and structural integrity of all girth welds meeting fracture mechanics criteria as represented by the November 26, 1976, decision curves, there remains, however, a question as to those welds containing defects which pass neither the DOT standards nor the decision curve criteria. The weld quality sampling program results list eight such welds all performed during the 1975 construction season.

The true value of any sample lies in its utility as evidence of the quality or character of the whole or entire lot. Thus, using the results of the girth weld sampling program, it is possible to make certain estimations regarding the total number of girth welds containing defects which fall beyond the limits of the November 26, 1976, decision curves. Applying statistical sampling formulae calculated to provide a 99 percent level of confidence, leads to an estimate that 0.1 to 0.9 percent (0.5%±0.4%) of all girth welds fall into this category.

Moreover, the individual sample defect length and depth measurements made by the ERDA experts, when displayed on the decision curves, provide an indication of the probable range of deviation and the maximum likely deviation of all such defects above the acceptable fracture mechanics determined sizes.

As noted in the November 26, 1976, decision, Figures 5 and 6, several sets of decision curves were proposed for evaluating the acceptability of planar and nonplanar flaws. The curves selected for use as part of that decision were the most conservative choices although the panel of five national experts convened by the DOT in October 1976 recommended otherwise. The panel in its November 8, 1976, report noted that the least conservative curves (i.e., the Irwin curves) "will most closely predict actual failures of non-crack defects." Moreover, in the decision itself, it was pointed out that while all DOT and outside experts agreed that fracture mechanics can serve as a basis for granting waivers, there are differences among those experts as to the degree of conservatism required, specifically as regards the choice of analytical models and factors of safety. Notwithstanding the technical merits of any particular model, it was the most conservative model that was chosen to carry out the November 26 decision.

To assist the DOT in evaluating this information and determining its significance to the structural integrity of the pipeline, on June 6, 1977, the DOT reconvened the panel of five experts first convened in October 1976, in connection with the initial consideration of fracture mechanics technology. The panel of experts and their areas of expertise were: Dr. Herbert T. Corten, Professor of Theoritical [sic] and Applied Mechanics, University of Illinois (expert in fracture mechanics analysis); Dr. Matthew Creager, President of Del West Associates (expert in fracture mechanics analysis and testing); Dr. Robert C. McMaster, Regents Professor of Welding and Electrical Engineering, Ohio State university (expert in metallurgy, welding, nondestructive testing and radiography); Dr. Warren F. Savage, Professor of Metallurgy and Director of Welding Research, Rensselaer Polytechnic Institute (expert in metallurgy and welding); and Edward Criscuolo, Naval Surface Weapons Center (expert in welding and radiography).

That panel of experts concluded that:

1. The successfully concluded hydrostatic test, while useful in testing longitudinal welds and serviceability is not a significant test of girth welds;
2. The sampling program met the objective of determining with a high level of confidence whether or not the quality of welds meets DOT standards;
3. The November 26, 1977, decision curves, as they had previously noted, contain more than adequate safety factors;
4. None of the eight welds containing defects, which are only marginally outside the acceptable range of the November 26 decision curves, pose any threat to the structural integrity of the pipeline through its anticipated life;
5. Girth weld failures, which are generally an unlikely source of potential problems, will be even less so in the case of the trans-Alaska pipeline considering the superior materials and weld systems employed;
6. In view of the strong evidence that the 1976 field welds and the shop welds do not contain any defects which exceed the limits of the November 26 fracture mechanics decision curves, further review of these welds is not war-

ranted; and

7. Since the defect indications of the 1975 field welds are of neither sufficient size or number to be of concern with regard to structural integrity, further review of the radiographs of these welds will not furnish any additional useful information or increase the structural reliability of the pipeline.

A complete report of the panel's evaluation and recommendations has been placed in the public docket.

On the basis of the results of the sampling program, the technical analysis of those results by the panel and DOT experts, and the application of fracture mechanics analysis to these results, I have concluded that there is no more than an extremely remote risk of loss of pipeline integrity.

Accordingly, I have determined that further DOT review of the girth weld radiographs and related documentation will not serve any useful purpose and that any program to seek out and repair any girth welds would certainly prove costly and quite possibly environmentally disruptive with no perceptible likelihood of enhancing the structural integrity of the pipeline.

(18 U.S.C. 831–835, Section 6(e)(4) of the Department of Transportation Act (49 U.S.C. 1655(e)(4)) and Section 203 of the Trans-Alaska Pipeline Authorization Act (Pub. L. 93–153).)

Issued in Washington, D.C. on June 17, 1977.

ALAN A. BUTCHMAN,
Certifying Officer, OPSO.

MARGARET E. HAMMOND,
Deputy Secretary of Transportation.

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