

SCOMM

62:5

Alaska State Legislature

Senator Drue Pearce, Chair

Senator Tim Kelly
Senator Rick Halford
Senator Paul Fischer
Senator Al Adams



WHILE IN JUNEAU:
P.O. BOX V
JUNEAU, ALASKA 99811
(907) 465-4993

3111 C STREET, SUITE 150
ANCHORAGE, ALASKA 99503
(907) 561-2038

SENATE SPECIAL COMMITTEE ON OIL AND GAS

AGENDA

TUESDAY, JANUARY 30TH AT 3:30 P.M.

SENATE FINANCE - ROOM 518

TAPS Corrosion Overview and Technical Briefing by Alyeska Pipeline Service Company.

**Speakers: Jim Harle
Dave Hackney
Bill Howitt**

Overview by the Department of Law on the State's lawsuit against Alyeska Pipeline Service Company pertaining to the tariffs on the pipeline and \$200 M in corrosion repair.

**Speakers: Bruce M. Botelho
Douglas K. Mertz**

ALYESKA PIPELINE SERVICE COMPANY

CORROSION PROGRAM

Briefing for:

**Alaska State Senate Oil and Gas Committee
January 30, 1990**

ALYESKA PIPELINE SERVICE COMPANY
CORROSION PROGRAM

The Trans Alaska Pipeline System:

- Mainline Pipe
- Pump Stations
- Fuel Gas Line
- Marine Terminal
- Tankage
- Buildings
- Bridges

ALYESKA PIPELINE SERVICE COMPANY CORROSION PROGRAM

Purpose of Program:

- Assure System Integrity
 - Safety
 - Reliability
 - Throughput
 - Design Life
- Comply with Stipulations, Laws and Regulations
- Environmental Responsibility
 - No Leaks

ALYESKA PIPELINE SERVICE COMPANY CORROSION PROGRAM

Today's Topics:

- Mainline Corrosion Investigations
Corrosion Pig Development
Investigation Results
Repair Procedures
- Atigun Pipe Replacement Project
- Pump Station Piping
- 1990 Corrosion Costs
- Throughput Impacts

ALYESKA PIPELINE SERVICE COMPANY
CORROSION PROGRAM

Mainline Corrosion Investigation: Program Elements

- Corrosion Pig Surveys
- Data Evaluation and Prioritization
- Inspections
- Repairs

ALYESKA PIPELINE SERVICE COMPANY CORROSION PROGRAM

Corrosion Pig: Grading System

- PRIORITY 1: Impacts normal operating pressure
- PRIORITY 2: Impacts maximum allowable pressure
- PRIORITY 3: No impact on operation

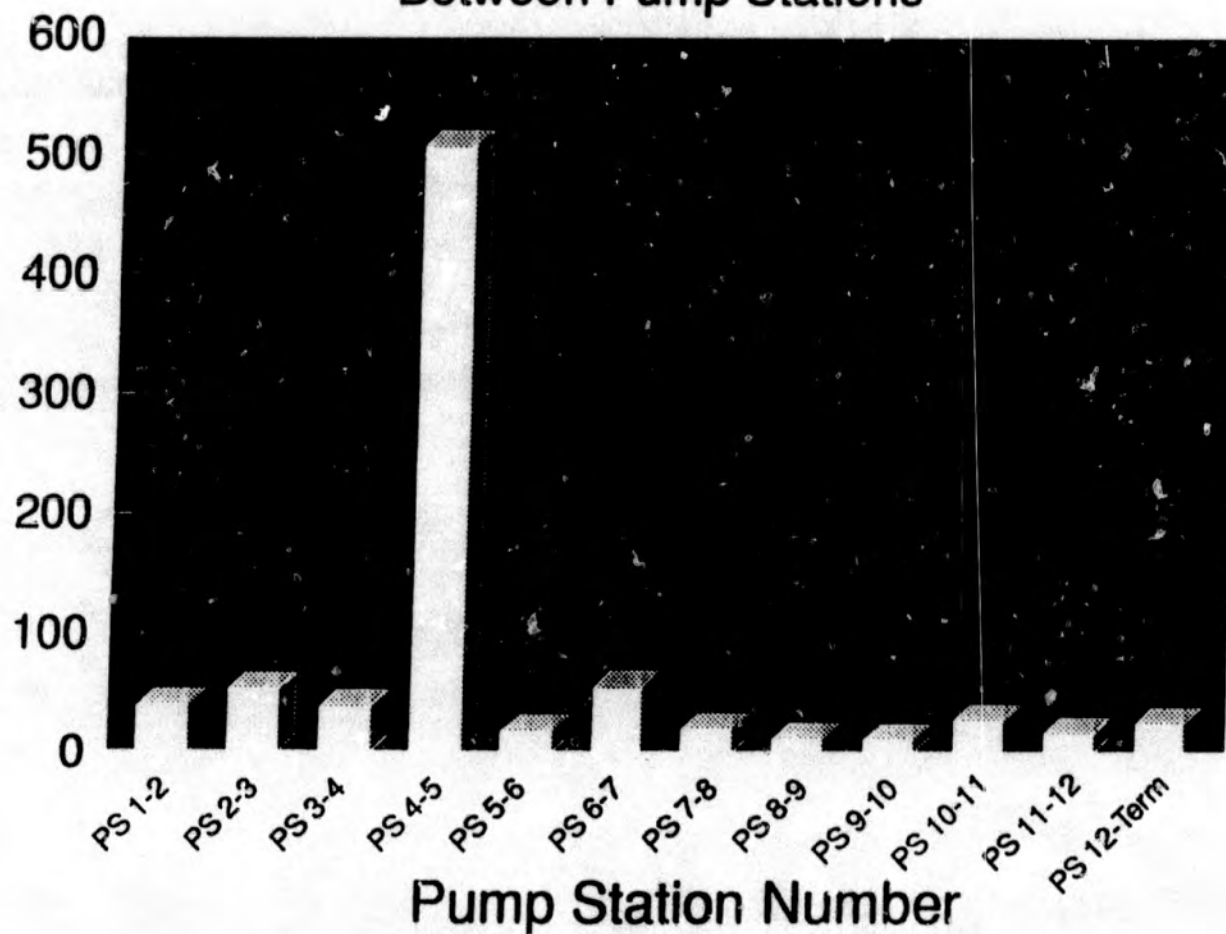
ALYESKA PIPELINE SERVICE COMPANY
CORROSION PROGRAM

Mainline Investigation Status: (January 15, 1990)

	Anomalies	Investigated To Date
Priority 1	116	113
2	195	64
3	<u>516</u>	<u>128</u>
Total	827	305
Repairs required:	30	

ALYESKA PIPELINE SERVICE COMPANY
CORROSION PROGRAM

Anomaly Locations
Between Pump Stations



ALYESKA PIPELINE SERVICE COMPANY
CORROSION PROGRAM

Mainline Investigation / Repair Procedure
(continued)

- Sleeve installed if necessary
- Corrosion protection system re-established
 - Epoxy coating system applied
 - Tape wrapped
 - Additional anodes installed
- Stability monitoring established
- Evacuation backfilled per engineered plan

ALYESKA PIPELINE SERVICE COMPANY
CORROSION PROGRAM

Atigun Floodplain Pipe Repair Project

- Majority of anomalies and repairs in segment
- Corrosion result of coating system failure
- Design and routing correct
- Repair options:
 - Recondition existing pipe
 - Install new pipe
- Probable schedule:

Engineering design	1989-90
Procure materials	1990
Construction	1991

ALYESKA PIPELINE SERVICE COMPANY CORROSION PROGRAM

Pump Station Corrosion

- Comprehensive inspection program
 - Define scope of problem
 - Establish priorities
- Mitigation program
 - Linewide inhibitor injection
- Monitoring program
 - Evaluate inhibitor effectiveness
 - Identify further corrosion

ALYESKA PIPELINE SERVICE COMPANY CORROSION PROGRAM

Pump Station Corrosion

Pump Station 3 Repairs

- Bypass station
No throughput interruption
- Replace corrosion damaged pipe
Design enhancements
Internally coat replacement pipe
- Scheduled completion
Early 1991

ALYESKA PIPELINE SERVICE COMPANY
CORROSION PROGRAM

1990 Anticipated Corrosion Program Costs
(\$ million)

Mainline	215
Pump Stations	50
Valdez Terminal	20
Pig Runs / Engineering	<u>15</u>
Total	300

ALYESKA PIPELINE SERVICE COMPANY CORROSION PROGRAM

1990-1991 Throughput Impacts

- Pipeline has greater capacity than North Slope production
 - 2.1 million barrels per day
 - 1990/91 production less than 2.0 million bbl/day
 - No lost production make-up capacity
- Pipeline slowdowns / shutdowns planned to minimize lost production
 - Scheduled field maintenance periods
 - Windows of opportunity

Anchorage Daily News

NO. 56 410 PAGES

ANCHORAGE, ALASKA, SUNDAY, FEBRUARY 25, 1990

PRICE

SPECIAL REPORT

Corrosion along the 800-mile
trans-Alaska pipeline could result
in a multibillion-dollar repair bill
costing the state millions in lost taxes

By **GEORGE FROST**
and **PATTI EPLER**

Daily News reporter

© Copyright 1990 Anchorage Daily News

The trans-Alaska pipeline, one of the biggest engineering feats of the petroleum age, is under fierce attack by an elemental force of nature.

The \$9 billion oil-delivery system is pitted with rust in hundreds of locations, and the repair bill could run into the billions of dollars.

Alyeska Pipeline Service Co., which runs the pipeline for the seven major oil companies that own it, vows the pipeline system is sound. Trouble spots are confined to isolated areas, Alyeska says. But the company stops short of assuring there is no chance of a rupture.

The danger of a disastrous oil spill is only one consequence of the pipeline's corrosion.

The state treasury also will be depleted. Pipeline owners are paying for repairs by raising their tariffs — or fees — for carrying the oil from Prudhoe Bay to Valdez. This higher fee lowers the value of North Slope crude and this year alone will cost the state an estimated \$21 million in taxes and royalties. In the next few years, the treasury could lose perhaps \$200 million due to corrosion repairs. And less oil revenue means the state will be sending Alaskans smaller permanent fund dividends each year.

Please see Page A-6, **PIPELINE**

Federal agencies caught off-guard by extent of corrosion

By **PATTI EPLER**
and **GEORGE FROST**

Daily News reporter

© Copyright 1990 Anchorage Daily News

In April 1988, Perry Francis gave the trans-Alaska oil pipeline his blessing.

"I am convinced that corrosion is under control on (the pipeline) and the corrosion program is working effectively," wrote Francis, a federal Bureau of Land

Management engineer, in a memo.

Less than six months later, Alyeska Pipeline Service Co. was reporting an alarming amount of corrosion on the 800-mile pipeline; more than 200 spots were suspected of serious rust.

Last July, 15 months after Francis concluded corrosion was under control, Alyeska quadrupled its estimate of

trouble spots. Alyeska said it would have to spend hundreds of millions of dollars to save the pipeline.

BLM and the federal Department of Transportation, both of which regulated the pipeline, concede they were caught off guard when substantial corrosion surfaced. Now DOT is investigating possible violations of federal law.

Both agencies are hiring more engineers and vow to scrutinize Alyeska more closely.

For the past 13 years, both agencies' oversight consisted largely of accepting whatever Alyeska told them about the pipeline and corrosion. They lacked expertise to interpret corrosion data supplied by the

Please see Page A-8, **REGULATORS**

WHAT HAPPENED?

The corrosion crisis has provoked an engineering and construction boom that could grow into the biggest Alaska project since the pipeline was built in the mid-1970s. Union hiring halls expect calls for hundreds of truckers, pipe fitters, carpenters and laborers in a corrosion fight that could continue as long as the pipeline moves oil.

Alyeska has assembled a team of hundreds of people to combat the corrosion.

The company has launched an accelerated repair program and last year welded new pipe over 31 spots where the main line was judged too weak to safely contain the crude.

Over the next three years, Alyeska says, it will spend as much as \$800 million on corrosion control. The state thinks the repair bill could top \$1.5 billion. No one knows the price tag for sure until Alyeska digs up more pipe and completes a thorough analysis, the company says.

The worst corrosion discovered so far has been confined largely to a 14-mile segment, 160 miles south of Prudhoe Bay, where the pipe is buried in a floodplain and its corrosion-protection coating is peeling off.

But throughout the 800 miles of pipeline Alyeska has found hundreds of problem spots.

The pipeline itself is not the only Alyeska facility under attack by rust. Other problems include:

- Interior corrosion at the eight northernmost of the pipeline's 12 pump stations has gotten bad enough to require \$50 million in repairs next year, with \$30 million going to rebuild Pump Station 3 just north of the Brooks Range.

- At the Valdez terminal, where 75 tankers call each month to haul crude oil to Lower 48 refineries, several key environmental protection systems have been riddled with corrosion for years, and storage tank bottoms are getting rusty. Repairs are costing at least \$125 million.

- Corrosion has attacked gas lines providing fuel to pump stations 1 through 4. No cost estimate for repairs is available.

- At North Slope oil fields, corrosion keeps dozens of technicians busy every day. Arco Alaska Inc. and BP Exploration (Alaska) Inc. will spend \$34 million this year to fight rust. For Arco, the Prudhoe Bay problem is so serious the company spends 20 percent of its field operating budget on corrosion.

Alyeska's corrosion problem has prompted an investigation by the federal pipeline safety office, according to Jack Overly, head of that agency's Denver office.

The company faces fines of hundreds of thousands of dollars if investigators find it broke safety rules building or maintaining the pipeline.

All metal is subject to decay. At its most elemental level, pipeline corrosion is simply the process of steel deteriorating into its original state. Energy used to turn iron ore into steel doesn't stick around forever; corrosion is the goodbye note.

The trans-Alaska pipeline is the nation's most important oil pipeline. Daily it moves 1.9 million barrels of hot petroleum — one-fourth of U.S. oil production — toward refineries that turn it into gasoline, jet fuel, heating oil, plastics and other petroleum products.

Almost half the pipeline is underground, an environment especially conducive to corrosion. The buried pipe is encased in a thick bulb of warm soil that has been thawed by the hot oil in the pipe. The melted soil conducts the electrical charges that cause corrosion far more readily than frozen permafrost.

"The warmer the earth from pipeline heat, the more active the corrosion," wrote A.W. Peabody, designer of Alyeska's corrosion system, in a 1979 technical journal.

Pipe buried in river drainages is particularly vulnerable because it's bathed in moisture.

The company says it always has done everything it could to stop corrosion. To do less, said spokesman George Jurkovich, would be to jeopardize "Goal 1," moving oil through the pipeline.

From before construction, oil executives promised the pipeline would be protected by the best means available. The steel was a special alloy, highly resistant to rust, they testified. The pipe was to be coated with a proven epoxy, and sealed with special insulating tape to keep out water and impurities that can cause rust.

Alyeska's corrosion plan in 1974 — the year construction began — promised to "insure the integrity of the pipeline from a corrosion standpoint over an operating life of 30 years."

Alyeska adapted familiar methods to fight corrosion in the harsh arctic environment, including visual and electronic inspections, and a buried "cathodic protection system" — miles of

draw off natural electrical currents that flow through the pipe and cause corrosion, weakening the steel.

STEEL EXPOSED TO ELEMENTS

But those safeguards may have been undermined even before oil began surging through the line.

The highly touted Japanese steel used in the pipe was not particularly resistant to corrosion, according to Harry Brandt, an engineering professor at the University of California at Davis who warned in 1972 the oil industry had exaggerated the quality of its steel.

Even the best steel will rust if it is mistreated. This pipe was exposed to salt air and spray during shipment from Japanese steel plants in 1969 and 1970. Some of the 100,000 lengths of pipe sat outside, exposed to Fairbanks snow and ice fog, for more than a year.

In 1971, all the pipe at the three storage yards in Fairbanks, Prudhoe Bay and Valdez got a protective coating of Scotchkote, an epoxy resin made by the 3M Co.

But the resin worked poorly, according to Bill Howitt, Alyeska's engineering manager. Some coating flaked off the pipe, exposing the steel. Alyeska calls this disbonding. The coating also cracked when the pipe was bent during installation. Alyeska sued, charging that 3M had altered the coating's formula and used an "inferior substitute." Attorneys for 3M argued the bare pipe was already so contaminated the coating could not be blamed. The lawsuit was settled in 1981 for an undisclosed sum.

Rather than strip off the bad coating Alyeska wrapped the pipe in tape, according to Howitt and others. Federal regulators approved the move during the last winter of construction as Alyeska pushed to finish the line. The first wrapping of tape didn't work, Howitt said, so the company rewrapped the pipe with a second layer.

In the Atigun floodplain, where the most extensive corrosion has been found, construction workers had serious problems wrapping the pipe. The pipe had to be heated to 200 degrees for the coating to bond, a difficult chore in minus 20- and minus 30-degree weather, Howitt said. The tape wrap was prepared and applied improperly, he said.

Today, most of the external corrosion appears to be caused by the pipe losing its seal of epoxy coating and protective tape, Howitt said. The pipe is getting exposed. This is an insidious problem that can't be prevented or detected before it causes corrosion save by digging up a lot of pipe, he said.

"Nothing protects against disbonding," he said. "Nothing."

A key question — so far unanswered — is whether the corrosion resulted from isolated defects, or a systemwide failure of the seals all along the buried sections of the pipeline.

Alyeska has known for years
Alaska's oil faucet was starting to rust.

The company found minor corrosion in the early 1980s when parts of the protective coating lost its seal, according to internal Alyeska reports. Throughout the mid-1980s it knew that its cathodic protection system was failing to protect miles of pipe, company reports show. And the company performed a major corrosion repair in 1988.

In 1983, Andy Smart, then Alyeska's chief corrosion engineer, proposed a \$70 million, six-year program that included retaping substantial sections of the pipeline, according to a federal Bureau of Land Management memo. BLM is the primary government regulator of the pipeline.

Don Knight, then BLM's chief corrosion engineer and author of the memo, said Smart frequently tried to persuade Alyeska management to focus on corrosion, with little success until 1983.

Smart declined an interview about his work at Alyeska.

Jurkovich, the Alyeska spokesman, denied any such proposal was made.

Any substantial corrosion-control work that engineers may have recommended was derailed by an extensive analysis by Battelle Petroleum Technology Center for Alyeska. Based on that study, Alyeska concluded in 1984 the pipeline was in "excellent condition." There was no evidence the pipe wrap and cathodic protection system were "suffering from accelerated deterioration," according to Alyeska reports.

So Alyeska reduced its corrosion-monitoring program. It would dig up the line about 12 times a year looking for corrosion instead of about 200. The company canceled plans to develop in-house a more sensitive "pig" — a high-tech device that runs through the pipe to check its shape and thickness.

Alyeska looked to other companies to develop a smarter pig.

NKK Corp. of Japan and a Canadian firm were separately developing more sophisticated pigs.

Pigs look for "anomalies" — deviations in the standard thickness of the pipe. Not all anomalies represent dangerous corrosion.

Earlier pigs could "see" anomalies at least a quarter-inch deep, or half the thickness of the pipe. The Canadian pig could pick up anomalies one-seventh of an inch deep.

In 1987, the Canadian pig turned up 14 anomalies. The next year a second run of the same pig showed 241 anomalies when engineers used a new method to interpret the data.

Alyeska engineers were skeptical they would find significant corrosion in buried pipe, Howitt said. But of the first 98 checked, 81 were

corrosion-related. A dozen damaged spots were repaired with pipe sleeves.

Last spring, the new NKK pig went down the line. The Japanese company promised its pig could detect anomalies of only one-twentieth of an inch deep. Altogether the smart pigs found 827 anomalies. Alyeska realized it had a serious problem.

Alyeska spokeswoman Marnie Isaacs said engineers are studying readings from the pig more closely using a different method to re-evaluate the data. The company expects to have many new points — perhaps thousands more — to investigate, she said.

FRUSTRATING WORK

Alyeska hired more than 300 workers last summer to begin digging up and inspecting the pipe.

The work is expensive and frustrating.

At one location, workers carefully peeled away 29 feet of frozen earth to reveal the pipe. After sandblasting off the protective tape and coating, workers eyeballed the pipe for corrosion and scanned it with infrared instruments. This single inspection cost \$2 million. It found no corrosion.

But other crews doing similar work found plenty.

Corrosion has been discovered at 202 of the 215 sites dug up so far, said Jurkovich, the Alyeska spokesman.

The worst segment, in the Atigun floodplain about 160 miles south of Prudhoe Bay, is to be replaced next year. Replacing nine miles of pipe will require a two-day shutdown of the pipeline.

Engineers fear they might lose pressure in the Prudhoe Bay oil column in a longer shutdown. That means thousands of barrels of oil that otherwise could be pumped might never be recovered. But Alyeska promises to get the job done in time by building an entire replacement section alongside the damaged pipe, making quick cuts to attach the new line, Howitt said.

THE STATE TAKES A LOOK

State officials say they were as startled as Alyeska says it was by the extent of the rust.

The state is concerned that repair costs are being added to the pipeline

from the price of oil before taxes and royalties get paid.

Chuck Logsdon, the state's chief petroleum economist, estimates the state will lose \$200 million if the tariff rises to cover \$800 million in corrosion-related expenses.

Late last year, Attorney General Doug Baily assembled lawyers, accountants and corrosion consultants to investigate. After their initial work, the state opposed adding corrosion cost to the tariffs in a protest filed with the Federal Energy Regulatory Commission, which oversees tariffs on U.S. pipelines.

The state alleges protective safeguards were undermined by the frantic pace of construction. Damaged pipe, defective wrapping materials and inadequate testing all may have contributed to later problems, the state says.

"If it was foreseeable and they knew they had problems and could have avoided it, at some point they can't roll that cost into the tariff and they can eat those costs," Baily said.

Alyeska attorneys argue the state gave up its right to challenge tariff increases caused by defective design, construction and maintenance in 1985, when it signed an agreement to settle a dispute over pipeline tariffs.

The state has established a pipeline office and is planning to share office space and technical information with BLM.

"We are expecting the monitoring and corrosion to be an ongoing issue," said Jerry Brossia, who heads the new office.

Brossia said the state made a serious mistake by ceding authority and responsibility for pipeline monitoring to the federal government.

"It's foolish and certainly imprudent not to be actively looking at it," he said.

When the state opted out of oversight, scrutiny of the pipeline fell on BLM and the DOT's pipeline safety office, both of which concede they didn't have the expertise to analyze pig results or perform independent analyses of corrosion.

Both BLM and DOT are expanding their budgets to look closer at the pipeline problems.

Congress also is starting to pay attention.

U.S. Rep. George Miller, D-Calif., who chairs an Interior subcommittee challenging oil company practices in Alaska, links pipeline corrosion to opening the Arctic National Wildlife Refuge east of Prudhoe Bay to oil development.

The oil industry "wants us to extend the life of that system another 25 to 50 years by allowing new drilling onshore and offshore," Miller said. "They tell us everything is just fine... that it's state of the art. Well, I think there's some question as to whether or not that's true."

REGULATORS: Agencies caught off-guard by the extent of cor

Continued from Page A-1

company and never hired consultants to help them out.

The April 1988 memo from Francis lauding Alyeska's corrosion effort is a case in point. Francis wrote it after only reviewing a 45-page company report and talking with a senior Alyeska engineer, according to his memo.

BLM is the main pipeline watchdog. DOT's pipeline safety office is in Denver, and officials there rely on BLM for information.

The state, pleading lack of money, shut down its oil pipeline monitoring office in 1979. Last fall, driven by the public outcry over the Exxon Valdez oil spill and the discovery of substantial corrosion, the state resurrected the office.

BLM said it's doing an effective job.

"I don't believe there's another pipeline in the United States ... that gets the scrutiny the trans-Alaska pipeline gets," said John Santora, deputy director for minerals for BLM.

Francis said he spends half his time in the field, and when he's not there another BLM inspector

is. "I can't say we've seen all the corrosion that's been dug up," Francis said, but he thinks officials understand the problem and how Alyeska is working to solve it.

Alyeska is required to reimburse BLM for any expenses. Alyeska pays the salaries of BLM engineers and other staff. Pipeline inspectors fly on Alyeska helicopters, stay in Alyeska housing and drive Alyeska trucks. Alyeska knows when inspectors are coming and where they're going.

BLM officials say Alyeska does not dictate their budget. BLM sends Alyeska a bill and Alyeska has never quibbled over payments, they say.

Through the 1980s, that bill got smaller. BLM cut its budget every year from 1982 to last year, when corrosion became a significant problem, according to BLM reports. The budget fell from \$1 million in 1982 to \$300,000 in 1987, before rising to \$500,000 last year. Staffing fell from 24 workers to six today.

Mike Menge, head of BLM's pipeline office for the past 20 months, said BLM cut spending due to a higher degree of confidence in the pipeline and

Alyeska. "Over time, an awful lot of the anxiety associated with the original construction went away," he said.

The relationship has caught the attention of U.S. Rep. George Miller, D-Calif., chairman of a subcommittee scrutinizing the Alaska oil industry. Miller prompted the General Accounting Office to investigate pipeline corrosion and whether BLM and DOT have shirked their duty to the public.

"I think what's happened over the life of this project is that everyone's gotten far too cozy," Miller said. "I think the policy makers have bought into the company line, which is, 'We know what we're doing.' I think that now has been discredited and if those relationships (between BLM and Alyeska) need to be changed, then so be it."

Menge said he trusts the integrity of his staff.

"The bottom line is you just have to do your job and not take anybody's word for anything," he said.

Yet BLM reports reflect mainly Alyeska's corrosion work and not independent checks by federal agencies.

BLM also appears to have assumed the role of a protective

big brother to Alyeska.

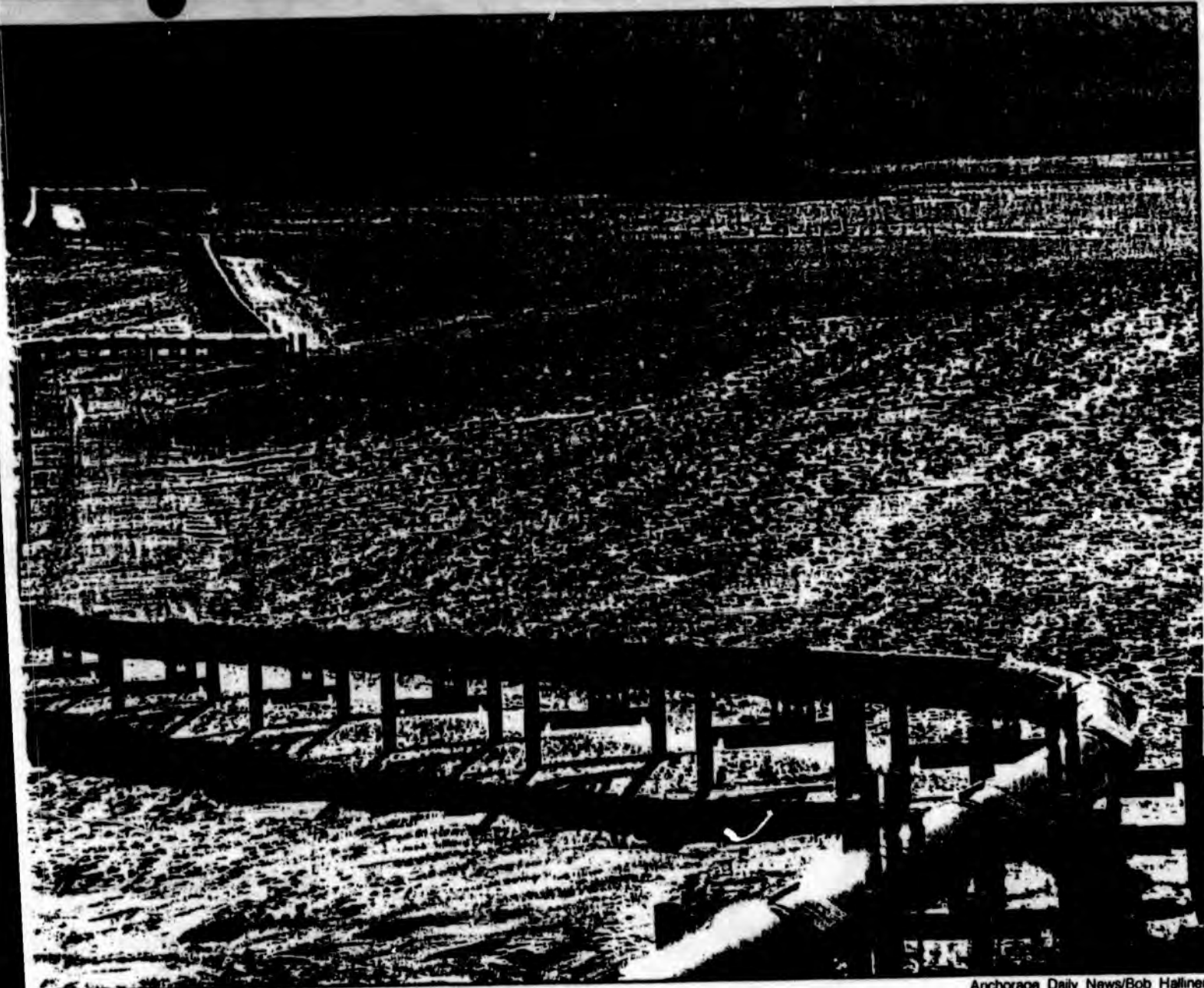
Last December, weeks after Alyeska had already briefed the press, legislators and other officials on the extent of corrosion, BLM's Santora refused to say how much corrosion had been found until getting clearance from Alyeska. When BLM called Alyeska, a secretary rushed in to interrupt George Jurkovich, a company official, from a meeting.

"I said, 'What are they asking us for? We've been telling everybody and his brother that (number) for months,'" Jurkovich said.

Since the corrosion issue arose, the DOT has started making annual visits to Alaska, said Jack Overly, head of DOT's Office of Pipeline Safety in Denver.

Mainly inspectors review Alyeska records, although they do accompany Alyeska and BLM officials on a tour of the pipeline, he said.

Last year inspectors also started coming to Alaska to check out safety problems, he said. Alyeska is required to notify DOT when corrosion reaches a certain depth in areas under high pressure and could pose a threat to the line. The company sent DOT a flurry of those reports last spring and they've continued



Anchorage Daily News/Bob Hallinen

ear Pump Station 4 in the Brooks Range

Overly couldn't say how much his office spends to oversee Alyeska. He said the office has a travel budget of about \$80,000 a year to visit dozens of pipelines in 12 states, including Alaska.

DOT has three engineers on staff and is proposing to hire two or three more in the next few years to deal with the Alaska pipeline, Overly said.

One new DOT engineer may wind up being stationed in Alaska, working out of an office shared with the state and BLM. The three agencies hope to team up to finally get a regulatory grasp on the corrosion problem.

The state, facing the loss of hundreds of millions of dollars in taxes and royalties as corrosion repair bills climb, has hired a firm of corrosion experts from Ohio to conduct an independent investigation.

But BLM continues to look to an unprepared DOT for help in sorting through the reams of technical data and reports being produced by Alyeska.

BLM staffers lack expertise to understand Alyeska's data, Menge said. "We rely on DOT's experts for that," he said.

"We don't have that expertise," said Overly.



Other problems along the line

By PATTI EPLER

Daily News reporter

© Copyright 1990 Anchorage Daily News

The trans-Alaska pipeline is not the only piece of Alaska's oil machinery in need of major overhaul.

Here is a summary of the major problems from Prudhoe Bay to Valdez.

THE PUMP STATIONS

A significant portion of the piping at Pump Station 3 on the northern flank of the Brooks Range will be replaced within the next year. Corrosion caused by a bacteria has devastated the pipe.

The \$30 million repair job includes removing and replacing hundreds of feet of pipe within the pump station, and involves slowing the flow of oil through the main pipeline for perhaps a month.

Alyeska Pipeline Service Co. has budgeted \$50 million to deal with pump station corrosion this year, including work at Pump Station 1 at Prudhoe Bay, which will require a half-day shutdown of the pipeline.

The bacteria is in water that accompanies oil through the pipeline. The corrosion occurs in "deadlegs," pump-station pipe installed for a future connection but never hooked up, according to Bill Howitt, Alyeska engineering manager.

Alyeska discovered the bacteria and related corrosion in 1988. Since then the problem has crept south to infect eight of the 12 pump stations that keep oil moving along the 800-mile pipeline. More than 1,200 deadlegs are suspected of having bug-related corrosion. Alyeska has inspected 800 and found corrosion in more than 120 spots, but only seven have been serious enough to require immediate repair, Howitt said.

WET INSULATION

Pipe buried in the permafrost beneath many pump stations became wet after just a few years of pipeline operation, and the company began finding extensive pitting.

Howitt said Alyeska is about two-thirds through a multimillion-dollar, six-year program to repair and reinsulate buried pipe. Alyeska has put in a new corrosion-control system that is designed to work when insulation gets wet, Howitt said.

CHEAP PIPE

At the Valdez shipping terminal, Alyeska has patched and replaced miles of corroded pipes carrying oily ballast water from tankers to a treatment plant.

Rust has attacked two different sets of carbon steel pipelines. Such pipe is cheaper than stainless steel but more easily corroded.

It took \$30 million and two summers' work to reline with a fiberglass coating nearly five miles of pipe running from tanker berths to holding tanks at the treatment plant, said Chuck O'Donnell, terminal superintendent.

And this year the company plans to spend \$11 million replacing another 3,700 feet of above-ground pipe with stainless steel lines, he said.

AIR POLLUTION CONTROLS

Alyeska's air pollution control system in Valdez has deteriorated almost from the day it began operating, costing the company at least \$35 million in repairs.

Three giant incinerators that burn toxic oil vapors are being rebuilt at a cost of about \$22 million. A \$5.5 million machine to remove condensation that corrodes pipe is being installed. And repairs to the pipes themselves are running in the millions of dollars.

So far, Alyeska has replaced about a mile of pipe, in some cases using more rust-resistant stainless steel instead of the original carbon steel pipe, O'Donnell said.

OIL FIELD RUST

The battle against corrosion at aging North Slope oil fields has escalated dramatically in the last three years, as engineers fight off corrosive acids, microscopic bugs and the arctic weather.

North Slope operators have more than doubled their spending on corrosion-control programs in the last two years — from \$34 million in 1987 to \$71 million in 1989 at the Prudhoe Bay field alone.

"I'd say there's not a week that goes by" in which the engineering staff doesn't face a new corrosion problem, said Bill Patterson, an Arco Alaska Inc. corrosion engineer.

"Any place you've got water in contact with metal you've got a potential for a problem," said Don Scheve, Arco's Prudhoe operations engineering manager.

There's lots of metal and water on the North Slope. At Prudhoe Bay, the largest oil field in North America, each of the 800 producing oil wells has 20,000 feet of steel casing and tubing. About 900 miles of pipeline carry oil, water, gas and other liquids. The most troublesome water is the 42 million gallons daily pumped from oil reservoirs. This water production has doubled since 1987, said Doug Webb, BP Exploration (Alaska) Inc.'s operations vice president.

BP has replaced more than two miles of pipe but never had a leak, Webb said.

Arco hasn't been as lucky. Two winters ago, leaks developed in an oil and gas line on Arco's half of Prudhoe Bay. The company replaced about three miles of pipe.

"That was the worst we'd seen at Prudhoe Bay," Scheve said.

Arco replaced a total of another seven miles of pipe in 1988 and 1989, Patterson said.

Trouble on the trans-Alaska pipeline

How corrosion is affecting the 800-mile pipeline

Corrosion is an electrochemical process that weakens metal by stripping away charged subatomic particles called ions. A corrosion circuit works much like a car battery with electricity flowing from an anode to another point called a cathode. The electricity flows through water, soil or acid.

How corrosion is affecting the buried sections of pipeline

The trans-Alaska pipeline is protected from corrosion by several safeguards. First it is coated with an epoxy that bonds to the steel. Next, the epoxy coat is wrapped in a special tape designed to keep out moisture. Finally, ribbons of zinc or bags of magnesium are attached to the pipe to divert electrical currents away from the pipe. Because they conduct electricity more easier than steel pipe, these sacrificial metals are supposed to corrode instead of the pipe. This is called a cathodic protection system.

1 External corrosion results from a failure of the epoxy coating and tape to keep water and acids away from the pipe.

Layer of protective tape

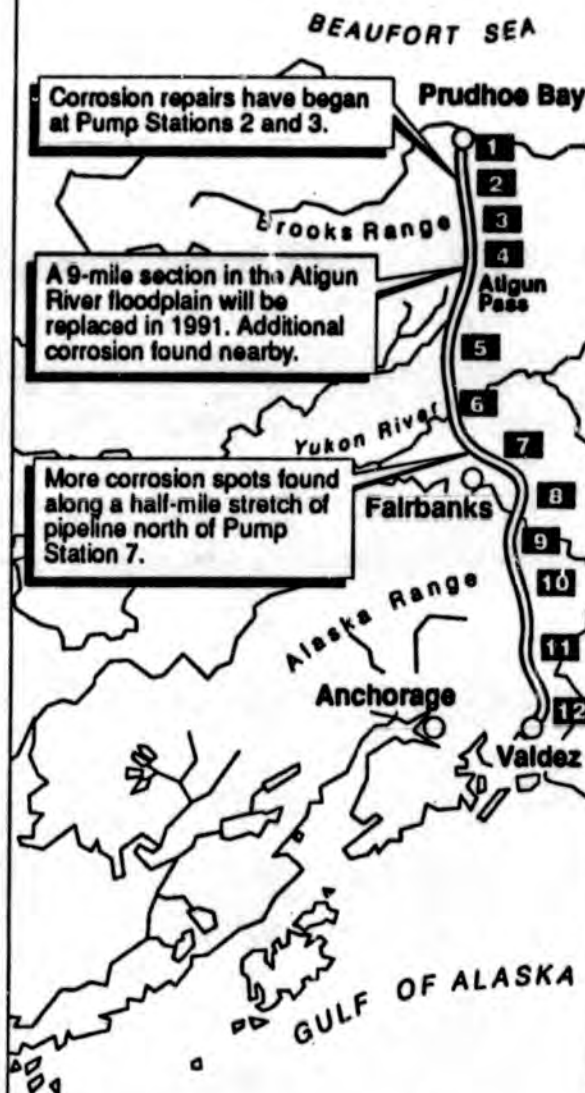
Epoxy paint

1/2-Inch thick steel pipe

2 A failure of the cathodic protection system to divert electricity to the sacrificial anodes further enhances the possibility of corrosion.

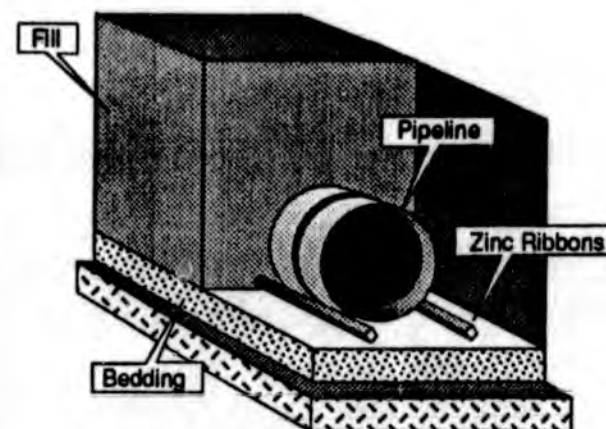
Zinc ribbon anodes

3 Water and acids begin to rust the steel pipe turning it to iron oxide.



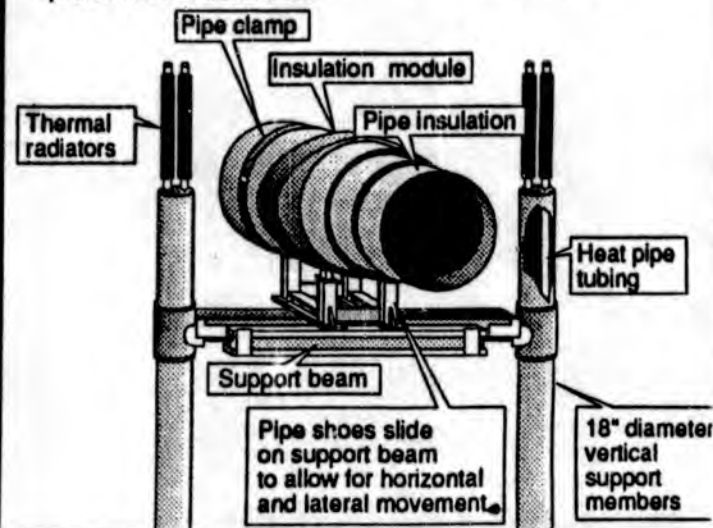
Cross section of buried pipeline

The Trans Alaska Pipeline is buried where stable soil and rock permit. A short section at Atigun Pass is buried in an insulated box atop a concrete slab.



Cross section of elevated pipeline

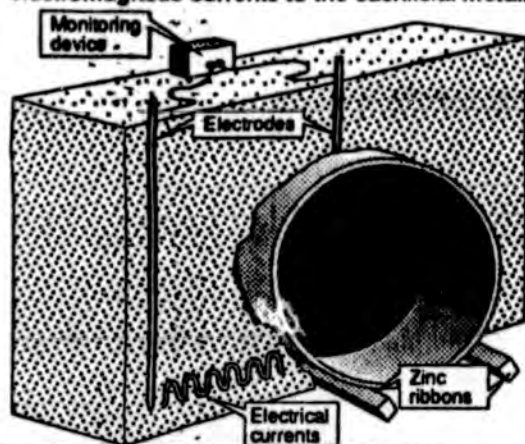
Above-ground supports, located every 60 feet allow for movement to accommodate expansion and contraction of the pipe or possible seismic disturbance.



How Alyeska monitors corrosion on the pipeline

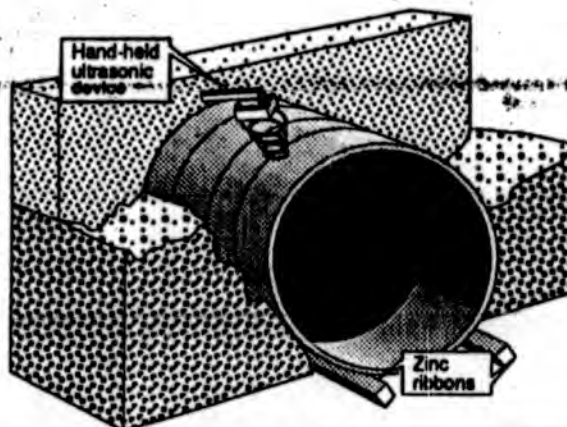
1 Annual surveys

Surveys are made of the pipe to measure the potential for electrical currents to flow from the pipe through the soil. Instruments measure whether the buried zinc strips are working. The zinc strips are part of the protection system designed to draw off electromagnetic currents to the sacrificial metal.



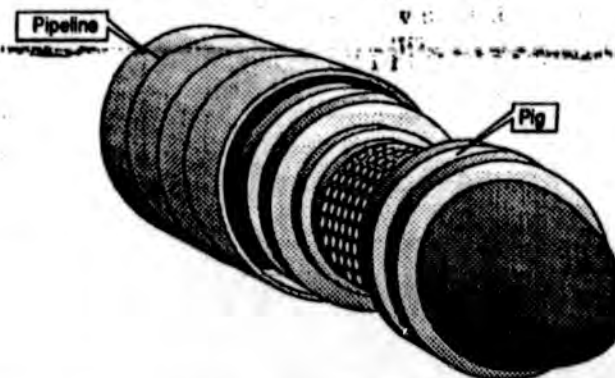
2 Digging up the pipe

The pipe is visually inspected for corrosion after stripping off the protective tape and epoxy coating. Hand-held ultrasonic instruments are also used to detect variations in the thickness of the pipe in areas where corrosion is suspected.



3 The corrosion pig

The pig is a self-contained tool equipped with 255 ultrasonic devices which measure the thickness of the pipeline wall by sending out sound waves and receiving the resulting echoes. It records readings for each square half-inch of the pipeline wall. The pig is 10 feet, 6 inches long, and 48 inches in diameter. It is made of titanium and weighs 6,600 pounds.



The Pipeline

Date oil was discovered: Nov. 20, 1968

Date construction began: 1974

Date oil was delivered: Aug. 2, 1977

Length: 800 miles

Pipe: Half-inch thick, 48-inches diameter

Construction cost: \$9 billion

Work force: 22,000

Length of pipeline buried: 400 miles

Number of vertical support members: 77,800

Highest elevation: 4,800 feet / Atigun Pass

Output: 80 million gallons of crude per day

Flow: 4.6 days to flow the length, at 7.35 mph

Temperature of oil: 140 degrees F

Capacity: 9 million barrels

