National Transportation Safety Board

Office of Railroad, Pipeline and Hazardous Materials Investigations

Washington, D.C. 20594

April 1, 2002

INTERNAL CORROSION TRAINING FACTUAL REPORT

Internal Corrosion Training Group Chairman

Mr. Charles R. Koval
National Transportation Safety Board
490 L'Enfant Plaza East, S.W.
Washington, DC 20594

Incident Identification

Location:	Carlsbad, NM
Date and Time:	August 19, 2000, 05:26 MDT
NTSB Accident No.:	DCA00-MP-009
Injuries:	12 Fatalities
Transportation Mode:	Pipeline
Operator:	El Paso Natural Gas Company

Operations Technical Development Program

At the time of the accident, EPNG had all employees who worked in the corrosion function participate in a program called the *Operations Technical Development Program* (OTDP). The first page of the OTDP contained a description of the program and the first sentence indicated that the purpose of the OTDP was to "ensure that the company continues to have a well-trained highly skilled workforce."

The OTDP defined five different disciplines, one of which was corrosion. The disciplines were then called functions, and the functions were divided into different tasks.[1] The tasks were created and listed by company experts from each discipline. The experts then classified each task into a skill level using three levels "A", "B", or "C." The "A" level tasks were defined as high-level tasks requiring more then 160 hours of training. The "B" level tasks required more then 8 hours of instruction, but less then 160

[1] The five functions were Controls, Corrosion, Maintenance, Pipeline and Plant.

hours of instruction. Finally, the "C" level tasks were called "routine tasks" and they required less then 8 hours of instruction.

After the tasks had been listed, the managers at each location identified the tasks performed at their locations and the employees who were to perform those tasks. The field personnel were encouraged to train and work cross-functionally. These field personnel were entitled Operation Specialists under the OTDP. The previously mentioned company experts (from each discipline) would review nominations for promotions from the Operations Specialist position to the Senior (function name[2]) Specialist position.

EPNG documents concerning the OTDP indicated that each location's (insert function name) Specialist position was to fulfill 5 requirements. All Senior (insert function name) Specialists: 1) "must be able to perform in all tasks in their functional specialty" and must be trained and test-verified in their specialty; 2) must accept responsibility for the integrity of the function within their location 3) must demonstrate the ability and willingness to instruct others within their function; 4) must meet location task requirements for Operations Specialists; and 5) must perform work outside their function to meet location work needs.

The OTDP was to be used by location management and employees to assess progress in training and testing/verification of tasks. Prior to performing a task independently, field personnel had to be tested/verified that they could perform the tasks. The OTDP called for these tests/verifications to be conducted by functional experts.

The OTDP was also used to develop plans for future training and testing/verification. Additionally, the OTDP called for annual reviews of employees' progress. A team of people consisting of at least the Location Manager, Lead Technician, Division Director, and Human Resources Representative formally reviews each employee's progress annually.

The OTDP stated that training and testing are separate activities and not done at the same time. For "B" and "C" level tasks, the testing was to be done by a two member location testing team including the Senior Specialists for each function. Testing on "A" level tasks were done by the senior functional member of the location testing team and observed by the Company Examiner. Testing of "A," "B," and "C" level tasks involve the test taker demonstrating or explaining each portion of the task to a testing team. The OTDP stated that Company Examiners are the most knowledgeable people in their discipline within EPNG. Company Examiners oversaw the qualification, including testing, for the Senior (insert function name) Specialist position.

[2] The five functions names were Senior Corrosion Specialist, Senior Pipeline Specialist, Senior Controls Specialist, Senior Plant Specialist and Senior Measurement Specialist.

Each location was to eventually have a Senior (insert function name) Specialist in each of the five disciplines/functions. At the time of the accident, there were 10 Senior Corrosion Specialists in the 16 Complex locations.

The senior specialist in the corrosion function, the senior corrosion specialist, was to be familiar with and know all tasks in the corrosion function specialty. The tasks were listed in the *Corrosion Function Task List.*

The Corrosion Function Task List

At the time of the accident, the *Corrosion Function Task List* was in place and it was the basis for EPNG's employee training program. The document itemized 61 different tasks. The "Corrosion Function Task List" was created when each task description was matched with a skill level. Of those tasks, 25 were level "A" tasks, 32 were level "B" tasks and 4 were level "C" tasks.

Examples of Level "A" tasks included 1) direction and inspection of new CPS (cathodic protection systems) & ground bed installations, 2) investigating/correcting interference problems, 3) knowing advanced knowledge of corrosion and cathodic protection, 4) operating a voltage meter to perform and record various corrosion work, 5) performing coating application inspections.

Most of the 25 Level "A" tasks were related to external corrosion. However, two of the tasks were written specifically to address the prevention of internal corrosion. The two tasks were: 1) maintenance and operation of a corrosion inhibitor injection pump, and 2) internal corrosion coupon analysis. Pipeline #1103 did not have any coupons and it did not have any inhibitor injected into it.

A Level "A" corrosion task that was related to internal corrosion control was the task of performing bell-hole inspections. When a pipeline was uncovered during a bell-hole inspection, the pipe would be ultrasonically inspected for internal corrosion. A bell-hole inspection form from an older manual (See Appendix 1 - Bell-Hole Inspection Report Form) and employee interviews indicated that pipe would have been inspected for internal corrosion. A section of the form was for an internal corrosion inspection.

Two of the Level "B" tasks that were related to internal corrosion control were the same as the ones for level "A;" maintenance and operation of a corrosion inhibitor injection pump and bellhole inspections. Internal corrosion coupon analysis was not a Level "B" task. There were not any Level "C" tasks related to internal corrosion control.

Manuals Affecting Corrosion Control

The OTDP and the *Corrosion Function Task List* were not the only EPNG documents that would aid employees with corrosion control; EPNG, as required, had procedures related to corrosion control within their manuals.

El Paso Natural Gas Company (EPNG) continually updated their Operations and Maintenance (O & M) Manual and the corrosion control related section of this manual. The O & M Manual updates were published on the intranet to allow distribution to all company employees.[3] The corrosion control related section of the EPNG O & M Manual was updated on 1) May 1, 1997, 2) September 20, 1999, and 3) May 15, 2000. After the accident of August 19, 2000, EPNG also made subsequent changes to the corrosion control-related section of the O & M Manual. Those changes occurred on October 11, 2000 and December 13, 2000.

EPNG issued a separate Corrosion Control Manual on July 10, 2000. After the accident, the manual's internal corrosion control section was revised on January 15, 2001.

These EPNG Operations and Maintenance Manuals, as well as the later-developed Corrosion Control Manuals, outlined the corrosion control program for EPNG's pipeline system. Because the program changed with each manual update, Safety Board staff reviewed the different versions of the manuals. The review focused on sections of the manuals that pertained to corrosion control. Of particular interest was how the corrosion control sections of these manuals affected the internal corrosion control related training and qualifications of EPNG employees.

July 10, 2000, Corrosion Control Manual

Before the accident, the most recent company policy outlining procedures for corrosion control was a separate Corrosion Control Manual. This Corrosion Control Manual was dated July 10, 2000, and it was the first Corrosion Control Manual issued by EPNG. Previous to the issuing of the Corrosion Control Manual, EPNG had all of their corrosion control procedures addressed within their O & M Manual. At the time of the accident, EPNG's O & M Manual incorporated this Corrosion Control Manual by reference.

After this first Corrosion Control Manual was issued on July 10, 2000, every updated O & M Manual incorporated the Corrosion Control Manual by reference. Specifically, every updated O & M Manual's Corrosion Control Section referred to the Corrosion Control Manual within its heading and body.

Copies of the July 10, 2000 Corrosion Control Manual were distributed during a training session in early August. The manual had a "Section 700" entitled "Internal Corrosion Control." Section 700 started with pages on gas and liquid quality standards and went into the testing and sampling procedures for liquids, gases, and solids. Section 700 included scheduling for these sampling procedures, as well as other procedures related to corrosion control and monitoring. The last pages of this section pertained to safety and sample shipping requirements.

[3] Employees were shown how to electronically download the manuals during training sessions.

Section 700 stated "pipelines can be divided into two categories, pipelines transporting gases determined to be corrosive and pipelines that do not." The manual also states: "whether a pipeline transports 'corrosive gas' or not, can not be determined from the standards themselves. Water and other corrosive contaminants may enter the pipeline by accident or slowly accumulate in low spots. Only by regular monitoring and analysis can it be determined if pipelines are carrying 'corrosive gas'."

The first reference to a Corrosion Control Manual occurred before the July 10, 2000, Corrosion Control Manual was issued. The first reference of a Corrosion Control Manual occurred in the May 15, 2000 O & M Manual. The May 15, 2000 O & M Manual referred to the Corrosion Control Manual in the heading of the O &M Manual's corrosion control section, but not within the section entitled Internal Corrosion Control, Section 308.3.

May 15, 2000, Corrosion Control Section/Operations and Maintenance Manual

The Operations and Maintenance (O &M) Manual that became effective on May 15, 2000, had four sections (sections 308.1, 308.2, 308.3, and 308.4) related to corrosion control. The internal corrosion control section in this document was Section 308.3. The purpose of Section 308.3 was to define standards for control and monitoring of internal corrosion on pipelines.

Section 308.3 started with 4 general procedures: a) transported gas and liquids shall be tested to determine if they are corrosive and require further steps to minimize internal corrosion, b) any removed pipe or vessel or meter tube shall be opened so that the internal surface can be examined for evidence of internal corrosion, c) the condition of any previously described internal exposure shall be reported on the appropriate form, d) "if internal corrosion is found, remedial measures, as determined by Corrosion, to minimize internal corrosion will be initiated." "Corrosion," was not defined in Section 308.3, but EPNG indicated that it refers to Corrosion Services. EPNG also indicated that Corrosion Services consulted with field corrosion personnel to provide technical support and approval for all determinations, judgment, and analyses concerning corrosion issues.

Corrosion Services also made all determinations, judgments, and analyses in Sections 308.1 and 308.2.[4] Section 308.1 entailed the procedures for the design, installation, operation and maintenance of cathodic protection systems. Section 308.2 contained the procedures for control and monitoring of external corrosion on buried or submerged pipelines and structures. Section 308.1 was not related to internal corrosion prevention. The section had a sentence: "Corrosion control procedures must be performed by persons qualified by company operator education programs. Personnel not qualified must be observed and directed by a qualified person."

[4] Section 308.1 had a sentence: "All corrosion design, materials and installation must be approved by Corrosion prior to installation," and another: "A set of all corrosion control records shall be sent to Corrosion … " Section 308.2 had a sentence: "Additional monitoring must be performed at critical sources as determined by "Corrosion."

September 20, 1999, Corrosion Control Section/O & M Manual

The Operations and Maintenance Manual that became effective on September 20, 1999 had a section, Section 201.2, entitled "Corrosion Control." The scope of Section 201.2 "prescribes the minimum company requirements for monitoring and protection of metallic structures." Most of Section 201.2 related to external corrosion and its control. Other then item 14 that provided for the internal inspection of pipe when it was removed from the line or cut open, the one procedure related to internal corrosion control was item number 11 (on page 4 of 16):

> "If corrosive gas is transported or if internal corrosion is found, Corrosion Services or Field Services Corrosion will recommend the appropriate corrective action and establish an internal corrosion monitoring program to determine the effectiveness of mitigation programs. Internal corrosion mitigation will continue until monitoring and testing determines that the source of corrosion has been removed or other corrective actions have rendered the gas stream non-corrosive. Internal monitoring will be performed at least twice each calendar year, but with intervals not to exceed 7-1/2 months. Additional monitoring will be performed if necessary. A Remedial Action Form will be completed if internal corrosion is discovered on any portion of the pipeline or ancillary components and vessels containing natural gas."

After the corrosion control procedures, Section 201.2 had a section entitled "Qualifications." The section said: "The levels of qualification for corrosion protection personnel depend upon the individual tasks in which they are qualified." Section 201.2 referred to the previously described *Corrosion Function Task List* when it explained who could perform level A, B, and C tasks. Section 201.2 also stated that in the case of El Paso Field Services "corrosion technicians will be verified by Field Services corrosion personnel and/or attain a NACE[5] certification to at least the technician level." This level of certification requires that an individual take the Basic Corrosion Class and pass the accompanying test. This was the first of four NACE certifications in the generalist category.[6] The NACE Corrosion Technician certification can be obtained by taking the NACE Basic Corrosion Course, passing the test, and having two years of job experience.

The testing requirements for all "A," "B," and "C" level tasks were set out in Section 201.2. Section 201.2 stated that qualifying personnel in an "A" level task would require a examination consisting of a practical demonstration of all phases in each task. All qualification documentation was to be maintained in the Technical Development System, on the Maximo System. Before this edition of Section 201.2, all qualification

[5] National Association of Corrosion Engineers

[6] The certification above Corrosion Technician was the Corrosion Technologist certification, the next highest certification (in the generalist category) was Senior Corrosion Technologist, and the highest certification was the Corrosion Specialist. There were different classifications within the Corrosion Specialist certification based on an individuals engineering education.

documentation was kept in the Technical Development System. Even earlier, and well before this edition of Section 201.2, all qualification documentation was maintained by the Human Resources Department according to the Corrosion Control Section of the May 1, 1997, O & M Manual.

May 1, 1997, Corrosion Control Section/O & M Manual

Like the 1999 O & M Manual, the 1997 Manual had a Section 201.2, entitled "Corrosion Control." Section 201.2 had the same scope as the 1999 O & M Manual procedure that "prescribes the minimum company requirements for monitoring and protection of metallic structures from corrosion." Most of the 1999 edition of Section 201.2 related to external corrosion and its control.

The one procedure related to internal corrosion within the corrosion control section of this manual was item number 10 (on page 3 of 15). In post accident correspondence, EPNG stated that "item number 10 was established to satisfy El Paso's 49 CFR Part 192 regulatory obligation, pertaining to internal corrosion monitoring and control." Item number 10 was written identically to the procedure in item number 11 previously described in the 1999 O & M Manual. The Section 201.2 of the two manuals were similar except for a difference in how the current requirement at cathodic protection stations will be determined and an extra procedure in the 1999 O & M Manual restricting the timing of work on EPNG's Louisiana facilities.

The 1997 Section 201.2 had identical employee qualifications to the 1999 Section 201.2, but it said: "Senior Corrosion Specialists" training to verify in any corrosion task could receive training from a corrosion lead operations specialist in addition to a senior corrosion specialist, senior corrosion coordinator, principal corrosion coordinator or a consultant. Additionally, the 1997 Section 201.2, employee qualifications did not require that all Field Services corrosion personnel attain a NACE certification to at least the "technician level."

Employee Training and Qualifications

Training Records

Title 49 *Code of Federal Regulations* (CFR) 192.453 (I) indicates that corrosion control procedures must be carried out by, or under the direction of, a person qualified in pipeline corrosion control methods. NTSB staff requested and received the qualifications of EPNG's corrosion control personnel. (See Appendix 2 – EPNG Response to Information Request from NTSB.) In a related document, El Paso made the statement:

> "El Paso Natural Gas spends time, energy, and funds to train its personnel to acquire and continually improve their knowledge of corrosion and increase their ability to solve corrosion problems."

EPNG provided a list of Corrosion-Related Formal Training for 1997 – 2000. (See Appendix 3 - Corrosion-Related Formal Training for 1997 – 2000 & Scheduled 2001 Training.) The list showed that employees attended courses provided by NACE, Guardian and other contractors. Other than the NACE Basic Corrosion Course,[7] the Southern Gas Association Internal Corrosion Course and possibly the Corrosion Control Technical School, all of the courses, including training in the previously described Corrosion Function Tasks, were related to external pipeline corrosion. Not one of the courses specialized in internal pipeline corrosion.

Corrosion Control Personnel

Besides having senior corrosion specialists, El Paso also had the three corrosion coordinators to cover their approximate 10,000 miles of pipeline and related facilities. In the previously quoted El Paso document submitted to NTSB staff, EPNG stated that they "have three coordinators who have demonstrated their knowledge of corrosion control matters by their training and experience. These individuals conduct on-the-job training and conduct field tests of field corrosion personnel assigned tasks under the [operations] technical development program." Safety Board staff reviewed the qualifications of the 3 individuals.

The person who was in charge of corrosion at the time of the accident, the Principal Corrosion Coordinator, had taken and passed the first course given by NACE in the early 1970s, NACE I – Basic Corrosion. The Principal Corrosion Coordinator took and passed other NACE courses in the 1980's, but in a post-accident interview, the Principal Corrosion Coordinator stated that he did not have a NACE rating level. In his history at EPNG, the Principal Corrosion Coordinator has helped the company with its internal corrosion training program, developed internal corrosion mitigation and monitoring programs, and evaluated the job progression training and skill verification of corrosion control personnel. He has performed these duties while maintaining various corrosion-control supervisory positions.

The second coordinator, a Senior Corrosion Coordinator, was a certified NACE Corrosion Technician. Like the Principal Corrosion Coordinator, he helped with employee training while performing his regular work.

The third coordinator, also a Senior Corrosion Coordinator, was certified by NACE as a Corrosion Technologist one year before the accident. This individual had taken several NACE courses that related to external corrosion including 3 cathodic protection courses and a course for designing for corrosion control. He took one course related to internal corrosion control involving coatings and linings.[8] He also took 3 classes/seminars on cathodic protection at non-NACE schools.

[7] Corrosion Tasks Hands-on Training was listed on page 2 and half of the trainees took this course by home study.

[8] NACE does not have any courses that are strictly for internal pipeline corrosion prevention.

The three corrosion coordinators shared certain characteristics in their background. They had at least 19 years of corrosion control experience with EPNG (before the time of the accident). All three coordinators had extensive on the job experience, with the majority of that experience occurring in external corrosion control. All of them had worked in cathodic protection and corrosion testing. As stated earlier, the coordinators had been educated by NACE and took the Basic Corrosion Course. All of the coordinators were lacking a collegiate corrosion-related education.[9]

The Principal Corrosion Coordinator was based in El Paso and he worked in coordination with the other two senior corrosion coordinators. All three corrosion coordinators also worked as technical support personnel with the field corrosion technicians. One senior corrosion coordinator was based in Albuquerque and one senior corrosion coordinator was based in Tucson. EPNG did not have the same structure with support personnel, including corrosion coordinators, listed on the Midland Division personnel chart. The August 19, 2000, accident occurred within the Midland Division. EPNG noted that the Midland Division had access to the Principal Corrosion Coordinator or the senior corrosion coordinators.

NTSB staff reviewed the employee records of 6 other corrosion-related employees within the Midland Division. Four of these employees were Senior Cross-Functional Technicians during August of 2000. The other two employees were Senior Corrosion Specialists during the time of the accident. These two employees were promoted to the position of Senior Cross-Functional Technician in 2001. All 6 of the corrosion-related employees within the Midland Division had taken corrosion control training through NACE, along with some other corrosion control training. At least one of the employees also took an in-house corrosion-training seminar in 1996. Some of the NACE courses that the employees took were Basic Corrosion Protection, Cathodic Protection Theory/Data Interpretation, Protective Coatings and Linings, and Coating Inspection Training. All six of the employees took training for internal corrosion control in the year following the accident. Specifically, during the autumn of 2001, they took courses entitled "Internal Corrosion Control Training" and "Internal Corrosion Program Overview." These courses were taught by EPNG using a program outline created by the Southwest Research Institute, who had been hired by EPNG to prepare the curriculum.

Although not considered corrosion control personnel, both the North and South System controllers that were on-duty at the time of the accident had previously taken Basic Hydrogen Sulfide Gas Training. The training identified the basic properties and detection of hydrogen sulfide gas, and symptoms of exposure. The South System Controller had his training in 1986 and the other controller's was in 1990.

U.S. DOT Notice of Probable Violation Civil Penalty and Compliance Order

[9] A collegiate education is not mandatory for any part of 49 Code of Federal Regulations § 192 including § 192.453. A corrosion-related college education could be a degree in chemistry, materials science or metallurgy.

The Department of Transportation's *Notice of Probable Violation Proposed Civil Penalty and Compliance Order* (See Appendix 10 of Operation's Group Chairman's Factual Report) stated that El Paso established internal corrosion control procedures[10] to comply with regulations. The Compliance Order also stated the internal corrosion control procedures for Pipelines #1100, #1103, and #1110, are not carried out by, or under the direction of a person qualified in pipeline corrosion control methods because El Paso's corrosion personnel have not received the training (through either informal or formal instruction) necessary to perform the tasks to carry out the internal corrosion control procedures.

On October 12, 2001, EPNG submitted a response to the *U.S. DOT Notice of Probable Violation Proposed Civil Penalty and Compliance Order* (NOPV) (See Appendix 4 – Cover Letter and First 13 pages (Training Section) of EPNG's October 12, 2001 Response to the NOPV), which contested each item in the NOPV. The EPNG response stated "we believe this submission demonstrates that EPNG committed none of the violations alleged in the NOPV and at all times EPNG fully complied with the pipeline safety regulations and its own procedures." EPNG then stated that "so many tasks oriented toward internal corrosion control are not on the Corrosion task list on which the NOPV bases its allegation."[11] EPNG's submission had an attachment called an *OTDP Internal Corrosion-Related Task List*. The EPNG submission stated, "The NOPV's omission of numerous internal corrosion tasks mischaracterizes and seriously understates the extent to which EPNG's OTDP focused on tasks oriented toward internal corrosion control. When these tasks are counted it is evident that EPNG did sufficiently train its personnel in internal corrosion control."[12] The EPNG submission noted that the qualifications of EPNG's Personnel were not criticized in any DOT/OPS audit prior to the DOT's NOPV. According to the EPNG submission: "Audits that DOT, or the applicable state agency acting as OPS's agent, conducted have specifically addressed training or qualification issues, but no informal or formal concerns have been articulated about internal corrosion training."

Post Accident Changes to the EPNG Corrosion Control Manual

Data Review

Section 700, Part 1.1.3 in the *July 10, 2000, Corrosion Control Manual* stated, "Corrosion Control will make the final determination on whether a particular pipeline is transporting corrosive gas." Section 700 of the corrosion control manual issued on January 15, 2001 also contained this requirement, but it went further with the statement:

[10] These procedures were identified as *700 Internal Corrosion Control.*
[11] Page 12, 1st paragraph of EPNG's October 12, 2001 response to the U.S. DOT Notice of Probable Violation.
[12] Page 12, 2nd paragraph of EPNG's October 12, 2001 response to the U.S. DOT Notice of Probable Violation.

"An effective internal corrosion monitoring program requires all analytical and operational data as reported to be collectively reviewed and analyzed."

Responsibility

Unlike the *July 10, 2000, Corrosion Control Manual*, the *January 15, 2001, Corrosion Control Manual* had a section that states: "The Area/Complex Manager is responsible for maintaining a site-specific internal corrosion control action plan.[13] This plan will be developed by Corrosion Control Services and the Area/Complex Manager and reviewed annually."

Monitoring Frequency

The 2000 and the 2001 corrosion control manual's had different monitoring frequencies. Section 700 of the *January 15, 2001, Corrosion Control Manual* had both a "routine monitoring frequency" and a "mitigation monitoring frequency" for procedures (tests, probes, and sampling). The *July 10, 2000 Corrosion Control Manual* only had one frequency schedule for procedures (tests, probes, and sampling).

Liquid Sampling

Both the *July 10, 2000, Corrosion Control Manual* and the *January 15, 2001, Corrosion Control Manual* had a liquid sample monitoring frequency for non-corrosive gas streams of once per year and twice per year, not to exceed 7.5 months, for sections of pipe with corrosive gas streams.

The *January 15, 2001, Corrosion Control Manual* had a "mitigation monitoring frequency" for every procedure, including liquid sampling, of 2 times per year, "not to exceed 7.5 months."

Under the *July 10, 2000, Corrosion Control Manual*'s section on required procedures for liquid sampling, there is a sentence that stated "each gas stream may be assumed to be non-corrosive until Corrosion Control Services determines otherwise." The *January 15, 2001, Corrosion Control Manual* stated that "depending on corrosion monitoring results or other considerations, Corrosion Control Services may issue a written notification designating a gas stream in a section of piping as "corrosive.""

The *July 10, 2000, Corrosion Control Manual* stated, "A liquid sample should be collected when a gas pipeline, vessel, meter tube, or tank is opened for maintenance, removal, or inspection and liquids are present." The *January 2001, Corrosion Control Manual* stated, "A liquid sample, when available, must be collected when a gas pipeline, vessel, meter tube, or tank is opened for maintenance, removal, or inspection."

[13] All references of these two manuals are to Section 700 entitled "Internal Corrosion Control."

The *July 10, 2000 Corrosion Control Manual* used the sentence: "A liquid sample should be collected at pig receivers anytime the line is pigged." The *January, 2001, Corrosion Control Manual* has a sentence: "A liquid sample, when available, must be collected during pigging operations at pig receivers unless Corrosion Control Services recommends less frequent sampling."

With regards to liquid sampling, the *January 2001, Corrosion Control Manual* stated that one or more of the following tests may be performed on-site:

pH levels	Bicarbonate levels	Bacteria cultures
Total alkalinity	Dissolved H_2S	Temperature
Dissolved iron	Dissolved oxygen	Other tests as specified

The July 10, 2000, Corrosion Control Manual's on-site tests included pH levels and Bicarbonate levels as well as testing for "MIC"[14] and "total iron."

Gas and Other Sampling

In the *January 15, 2001, Corrosion Control Manual* there was a routine monitoring frequency for bacteria cultures, microscopic analysis, electronic probes and corrosion chemical residual monitoring. The *July 10, 2000, Corrosion Control Manual* did not list these procedures.

The gas sampling requirements in the *July 10, 2000, Corrosion Control Manual* and the *January 2001, Corrosion Control Manual* included data measurements for carbon dioxide, oxygen, hydrogen sulfide, sulfur, water content, and temperature. The *January 2001, Corrosion Control Manual* included a measurement of nitrogen and gas pressure which the *July 10, 2000, Corrosion Control Manual* did not have. Both the *July 10, 2000, Corrosion Control Manual* and the *January 2001, Corrosion Control Manual* had a note that referred to gas sampling frequency. The note stated: "Corrosion Control Services will determine procedure and frequency on an individual basis to monitor the specified system corrosion potential."[15]

Both the *July 10, 2000, Corrosion Control Manual* and the *January 15, 2001, Corrosion Control Manual*, contain a section entitled "Selecting and Preparing Sampling Locations" and both manuals suggested sampling at pig launchers/receivers, pipeline drips, vessel drain lines, tanks, scrubbers and meter tubes. However, the *January 15, 2001, Corrosion Control Manual* additionally suggested sampling at side streams and sample loops and low areas, sags, river crossings, etc.

Charles R. Koval
Internal Corrosion Training Group Chairman

[14] Microbiologically induced corrosion
[15] Page 6 of Section 700 of the *January 15, 2001 Corrosion Control Manual* and page 7 of Section 700 of the *July 10, 2000 Corrosion Control Manual*.