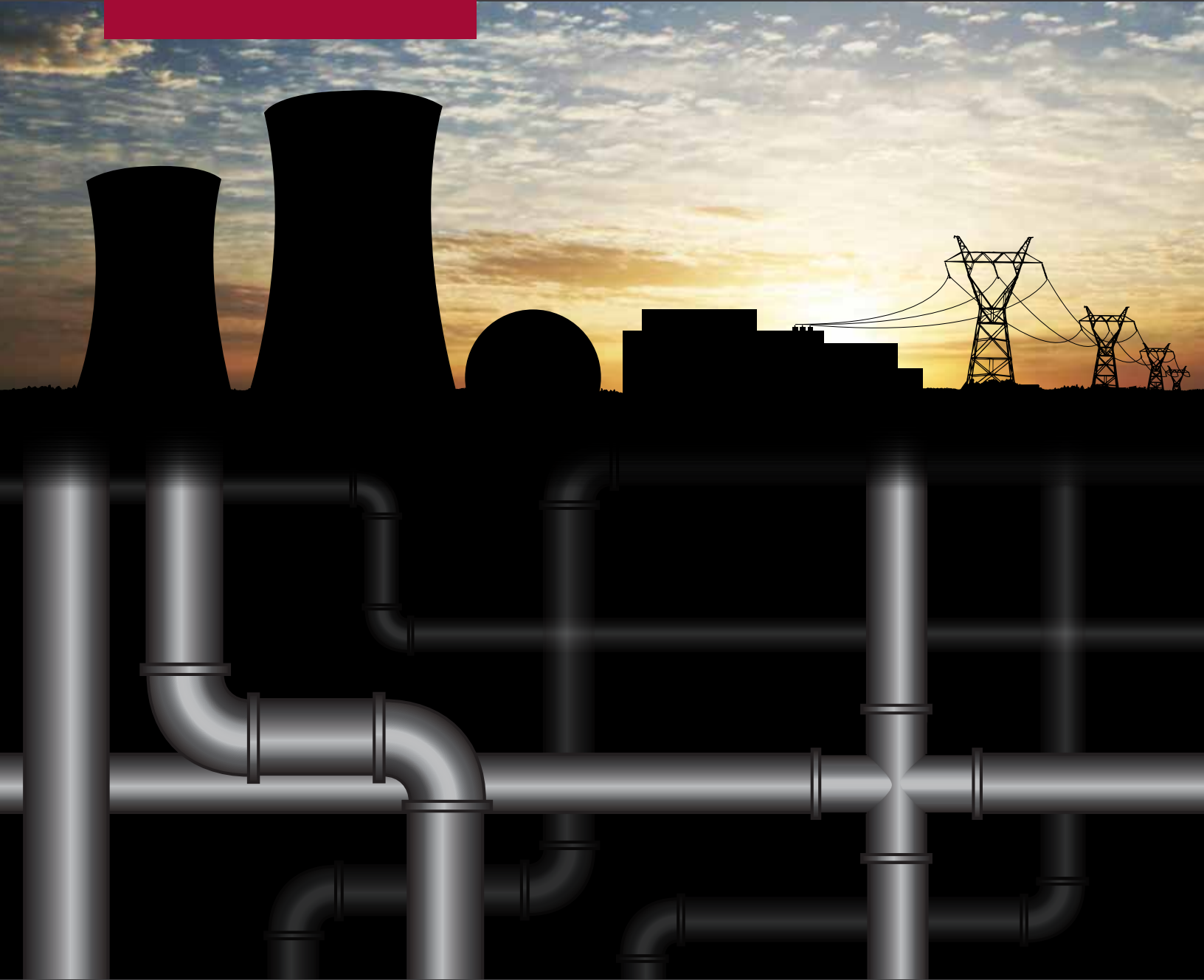








Structural Integrity
Associates, Inc.®

MANAGING BURIED PIPING & UNDERGROUND ASSET INTEGRITY



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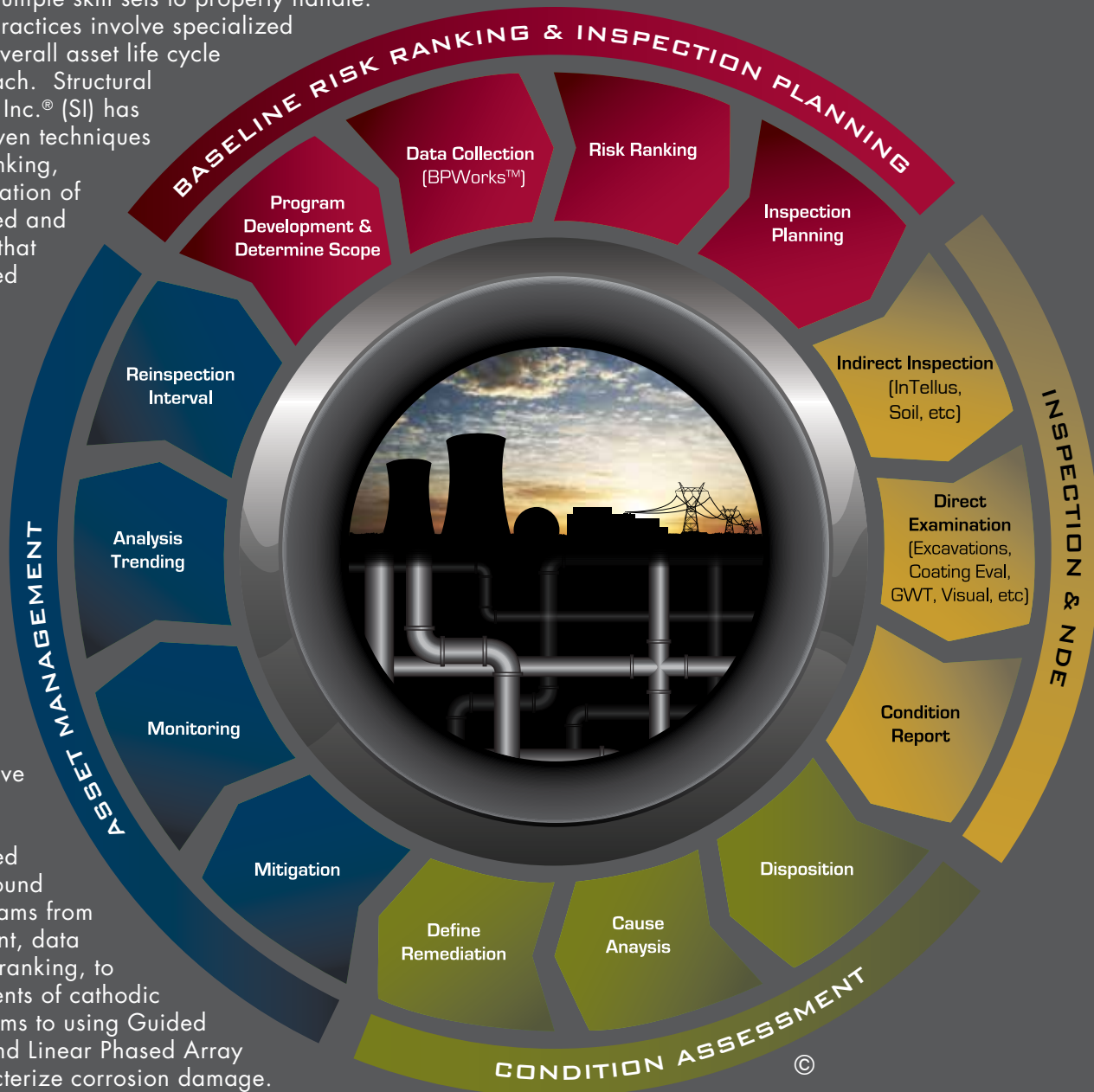
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MANAGING BURIED PIPING AND UNDERGROUND ASSET INTEGRITY

Evaluating and managing the integrity of buried piping and other underground Systems, Structures, and Components, especially those that contain radionuclides, in the nuclear industry is a challenging issue that requires multiple skill sets to properly handle.

The processes and practices involve specialized skills as part of an overall asset life cycle management approach. Structural Integrity Associates, Inc.® (SI) has established and proven techniques for the successful ranking, inspection and mitigation of degradation of buried and underground assets that can lead to improved plant safety and reliability.

Structural Integrity is unique in the industry in its offer of an integrated, multi-disciplinary approach to buried and underground corrosion concerns. We can assemble a multi-disciplinary team quickly to address virtually all corrosion issues. SI has the comprehensive expertise to assist in all phases of above ground piping, buried piping and underground asset integrity programs from program development, data integration and risk ranking, to conducting assessments of cathodic protection (CP) systems to using Guided Wave Technology and Linear Phased Array to locate and characterize corrosion damage. Once the foundation has been established, knowing how to disposition those findings and mitigate future degradation is critical. Integrating all available information (i.e., design, soil, groundwater, CP system operation, plant history, etc.) will lead to informed decision making and improved process management while shifting the focus from costly remediation to a proactive prevention plan.



Program Development Resources

- EPRI 1021175 (1016456, Rev1)
- EPRI 1016687
- NEI 07-07
- NEI 09-14
- NUREG-1800 XI.M41 (GALL)
- Independent MAP Review of Existing Programs

Data Collection

- EPRI BPWorks™ Database Population
- MAPProView™ - Component Digitizing & Data Visualization
- 3-D Component Modeling
- Ground Water Monitoring Wells



Risk Ranking

- BPWorks Database
- MAPPro Risk™
- Probabilistic Leak Evaluation

Inspection Planning

- Threat Assessment
- Criteria Development
- Acceptance Criteria
- Technique Selection
- Effectiveness Optimization
- Scheduling

Indirect Inspection

- InTellus – Coating Condition & Cathodic Protection (CP) System Effectiveness Survey
- CP System Design and Repair
- SoilPro – Site Selection, Soil Corrosivity Analysis, Corrosion Rate Calculations
- Guided Wave Testing

Direct Inspection

- Bell Hole Inspections (coating, CP, UT)
- Ultrasonic Wall Thickness Testing
- Electromagnetic Acoustic Transducer (EMAT) Testing
- Linear Phased Array UT and TOFD
- PT, MT, radiography

Condition Report

- Evaluation Support (Int/Ext corrosion modeling)
- Data Integration
- Fitness for Service
- Extent of Condition Analysis
- Life Cycle Management Assessments

Disposition

- Code Case N-513-3, N-597-1 Calculations
- Pre-Inspection Flaw Handbook
- Reinspection Interval Calculations
- Fracture Mechanics & Finite Element Analysis

Cause Analysis

- Metallurgical Failure Analysis
- Apparent/Root Cause Analysis

Remediation

- Repair Plan and Procedures
- Remediation Plan Development
- 3rd Party Design & Procedure Review

Mitigation

- Cathodic Protection System Design or Repair
- Coating Reconditioning: Selection / Design
- Materials Engineering: Selection / Design
- Groundwater (NEI 07-07) Program Integration

Monitoring

- Installation & Testing Services
- Cathodic Protection Test Stations and Wells
- Permanently Installed Guided Wave Collars
- Permanent CP Half-cells
- Corrosion Coupons (Internal & External)
- BloGEORGE™

Analysis Trending

- Corrosion Monitoring & Data Mining
- CP System Performance
- Ground Water Monitoring Wells
- Computational Fluid Dynamics
- Industry/Fleet Benchmark & Gap Analyses
- Assessment of Water Treatment Programs

Reinspection Interval

- Integrating Inspection Results, Soil Properties, CP, Coupons into Remaining Life Estimations

Training

- MAPPro and BPWorks 2 training
- Program Management & Risk Management
- Corrosion Principles & Threat Assessment
- Cathodic Protection System Management
- Direct Inspections
- Flaw Evaluations

LEVERAGING BURIED ASSET DATA WITH INTEGRATED ENGINEERING ASSESSMENT APPLICATIONS



NEI Initiative 09-14, *Guideline for the Management of Underground Piping and Tank Integrity*, established formal goals and responsibilities driving the industry to manage information about buried and underground pipe and tanks at nuclear plants to minimize unexpected failures and their impact. Deadlines were established for risk ranking buried pipe and ultimately conducting inspections on these systems to achieve reasonable assurance of structural and leak integrity. Structural Integrity has been an instrumental contributor to the industry on this emerging issue.

EPRI contracted with Structural Integrity in 2009 to develop the BPWorks™ 2.0 database and software interface. This database provides the industry with a robust data structure for storing and editing design, operating and inspection information for piping systems at a site.

To complement BPWorks™, Structural Integrity has developed the **MAPPro™ family of buried pipe applications**. These engineering tools allow utilities to:

- Perform external and internal corrosion-based risk ranking of buried pipe, tanks and other structures not currently addressed in BPWorks risk algorithms
- Import high volumes of data and evaluate the trends associated with cathodic protection, soil testing, tritium monitoring wells and inspection data (e.g., GWT, BEM, UT, etc.)
- Visualize all BPWorks and MAPPro database information in an interactive, graphical GIS environment through our MAPProView™ tool.

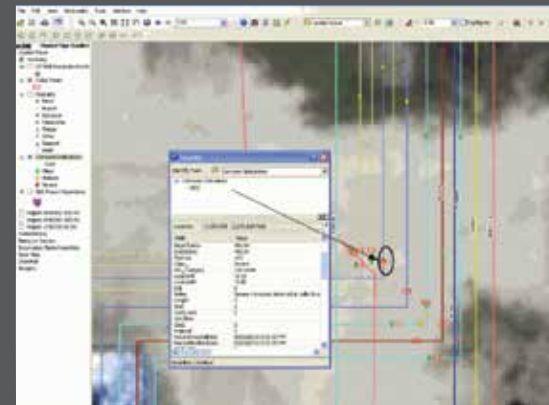


We have successfully aligned our specialized engineering and pipeline corrosion control experience to address buried pipe issues. A large portion of the domestic nuclear fleet is using our corrosion engineering expertise and software tools for data discovery, risk ranking, inspection planning, inspection execution, excavation evaluation support, coating condition and cathodic protection system evaluation (i.e., InTellus surveys), CP system design, flaw disposition, life cycle management studies, implementing corrosion control monitoring, and re-inspection planning.

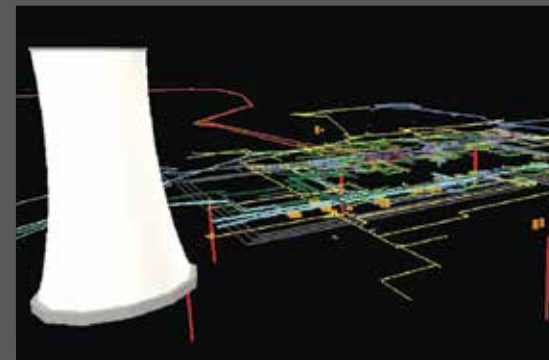
MAPPro™ USER COMMUNITY

Structural Integrity has created a **MAPPro User Community** to support the continued maintenance and development of user applications (aka MAPPro™ Apps). The benefits of this software support & maintenance agreement include 40 hours of custom support/year, participation in the guidance and development of new tools, as well as free access to all tools as soon as they are developed. The current list of applications available or under development includes:

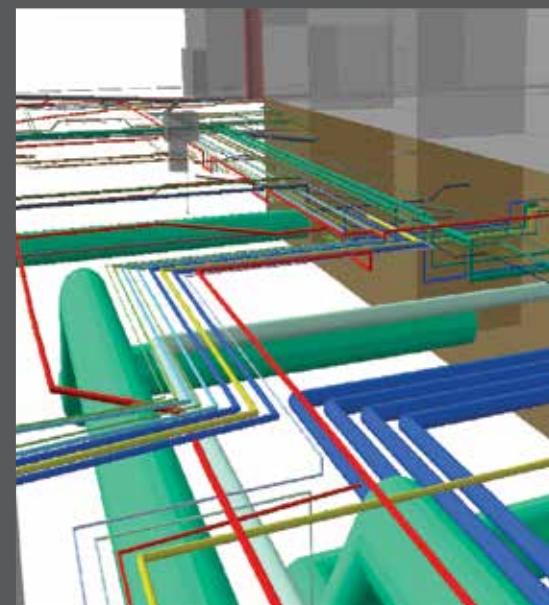
- **MAPProView™** – Structural Integrity’s data integration and visualization tool to allow system engineers to rapidly utilize database information, overlaid onto plant drawings or aerial imagery in either 2D or 3D. Photographs, as well as PDF and DWG files can be linked into this system for instant viewing. (pg. 7)
- **MAPPro Risk** – Addresses all pipe materials, fluid types, soil conditions, etc., and adjusts the risk model based on, but not limited to, corrosion mitigation (i.e. cathodic protection) and inspection results. It also provides the ability to adjust the risk model based on unique plant conditions or operating experience. (pg. 8)
- **MAPPro Tank** – Addresses tanks, sumps and other buried structures. Data can be managed in this module and used in risk calculations. The risk results can be evaluated alone or integrated with pipe risk results within the same system. (pg. 9)
- **MAPPro GWT** – Allows input and management of GWT inspection results such that they can be reviewed in BPWorks or MAPProView. (pg. 14)
- **MAPPro CP** – Imports Cathodic Protection measurements into BPWorks and performs trending analysis to expose issues. (pg. 11)
- **MAPPro InTellus** – Views and evaluates results from SI’s specialized coating condition and CP system effectiveness inspection technology, InTellus. InTellus data is also viewable in MAPProView. (pg. 12)
- **MAPPro Inspection Planning** – Identifies applicable NDE methodologies based on characteristics and can prioritize inspection dates based on risk ranking. Results can be exported or linked to plant site workflow management software. (pg. 16)
- **MAPPro LCM** – Calculates and displays leak evolution curves as part of a quantitative Life Cycle Management study. Probability and number of leaks can be plotted as a function of time for a single component or for a system. (pg. 20)
- **MAPPro Reports** – Extracts and presents data from the BPWorks database.
- **MAPPro Query** – Search the BPWorks database based on custom needs. (pg. 10)
- **MAPPro Cable** – Manage information about low and medium voltage cables as part of a Cable Aging Management program. Data can also be linked for viewing in MAPProView. (pg. 19)
- **MAPPro N513** – Applies the principles of Code Case N-513 to provide remaining wall thickness threshold guidance when performing excavations and UT inspection. Calculator can be used to generate preliminary flaw tolerance estimations in advance of an inspection or excavation. (pg. 17)
- **MAPPro Well** – Stores measurement data collected at tritium monitoring wells and lists the nearest buried pipe to the well. Data also linked to MAPProView for visualizing results as measured values change. (pg. 18)
- **SoilPro™** – Models measured soil parameters into effective pitting corrosion rate models for use in remaining life and re-inspection interval determination. (pg. 21)



MAPPro GWT



MAPPro Wells



MAPPro 3D

BPWorks™ 2.2 DATABASE SUPPORT



WHY IMPLEMENT BPWorks™

The BPWorks™ database is the new industry standard for managing buried pipe information at a nuclear site. It is a robust database for storing information with the potential to affect the internal or external corrosion potential of a buried or underground pipe. The database has fields to record data about the design, operation, internal and external environments, historical performance, inspection results, cathodic protection measurements and other corrosion control information.

WHY USE STRUCTURAL INTEGRITY?

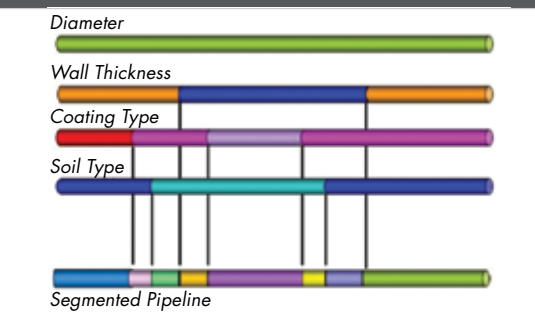
Structural Integrity was the vendor hired by EPRI to develop the latest BPWorks™ database structure and interface. We understand the data structure and the relationship between data tables. We use corrosion engineers with experience working at nuclear plants to review records, interview system engineers as part of the data discovery process and populate the database. We also provide access to a wide variety of additional engineering analysis tools (MAPPro™ Apps).



CONVERTING LEGACY DATABASES

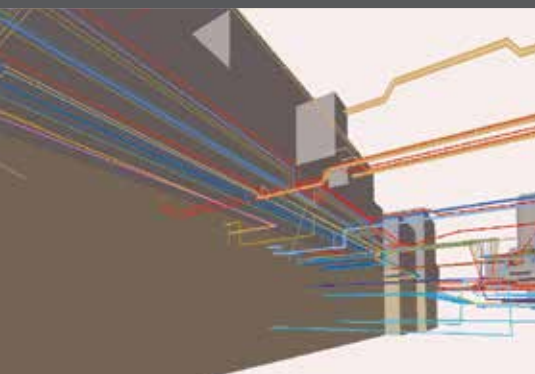
Structural Integrity created the BPWorks 1.x to 2.x import tool that accompanied the BPWorks software product. SI can help implement a standard conversation, aggregate prior segmented data (for dynamic segmentation purposes), or assist with acquiring supplemental data to enhance the value of risk ranking.

SI has successfully mapped and imported data from non-BPWorks data sources into BPWorks 2 – including the BManager™ data structure as well as various spreadsheet formats.



VISUALIZING BPWorks™ DATA IN MAPProView™

All data in the BPWorks and MAPPro database can be linked to MAPProView™. MAPProView allows for unlimited site access to the data in a read only format. MAPProView files are easily viewable and don't require software licensing.



MAPPro™ DATA VISUALIZATION

WHAT IS MAPProView?

MAPProView stands for **Managing Aging Piping Pro Viewer**. MAPProView is a core application in the MAPPro family of tools. This custom, easy-to-use desktop mapping application, developed by Structural Integrity, links to the data fields in the BPWorks™, MAPPro, and other database. This GIS (Graphical Information System) viewer is built on the ESRI ArcGIS application platform. The viewer allows multiple users to view, explore, and print maps. ArcReader, a free application, is required to view MAPProView.PMF files.

MAPProView allows for unlimited site access to the data in a read only format. Synchronization to database changes is also available.

VISUALIZING BPWorks™ DATA IN MAPProView™ 2D/3D

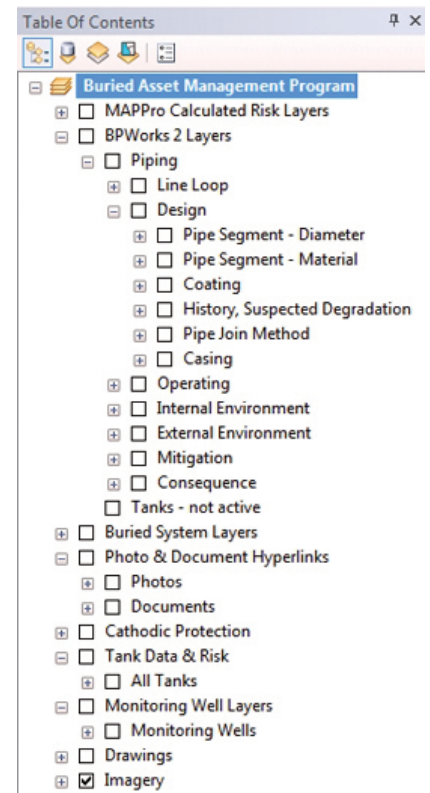
All data in the databases is linked to MAPProView™ 2D or 3D. To view data and other information in MAPProView, plant piping, structures, roads, water features, etc. must be drawn (digitized) in a GIS environment. Plant drawings (yard, isometrics, details) that show pipe, tank, grounding grid, CP & monitoring well locations, etc. are used in this process. Once these features are created, database information can be linked.

A major advantage of GIS integration is that multi-variant data conditions can be symbolized for representation or complex spatial analysis. Data attributes can change color, shape, style or size based on their value or condition. Unlike traditional relational databases, this spatial database can identify conditions that are within proximity to other data representing points, lines or shapes.

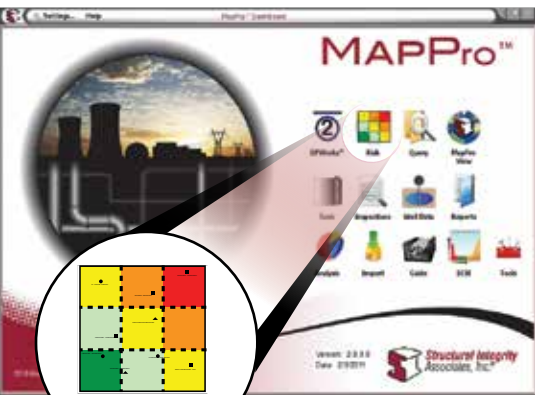
MAPProView™ 2D/3D

MAPProView is available in both 2D and 3D versions. In addition to linking to BPWorks and other databases, photos, GWT features, and reports (e.g., DOC or PDF files) can be hyperlinked to any digitized feature for rapid access. Plant drawings or aerial imagery can be used as pipe backgrounds.

MAPProView 3D offers value in uses ranging from excavation planning to tritium release investigations and inspection planning. Soil topology and ground water table data can also be integrated into this tool.



MAPPRO™ RISK (FOR PIPE)



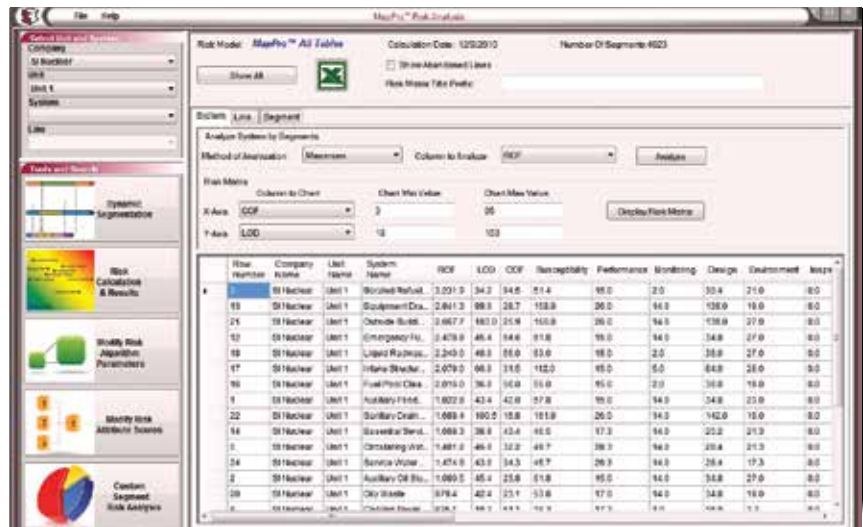
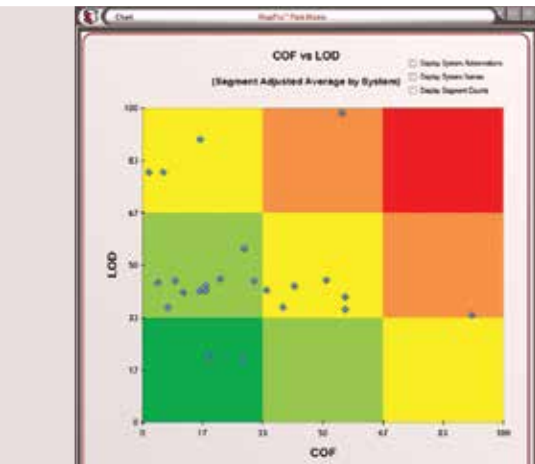
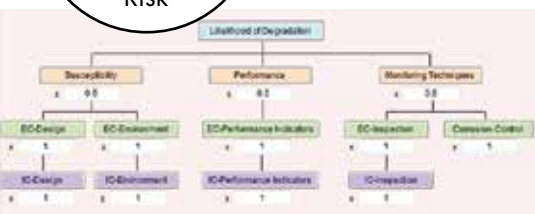
CUSTOMIZED RISK ANALYSIS

Establishing the corrosion risk of buried structures requires consideration of all likely corrosion mechanisms. The risk model should address the influence of all material types, process fluids, inspection results and corrosion control/corrosion mitigation measures.

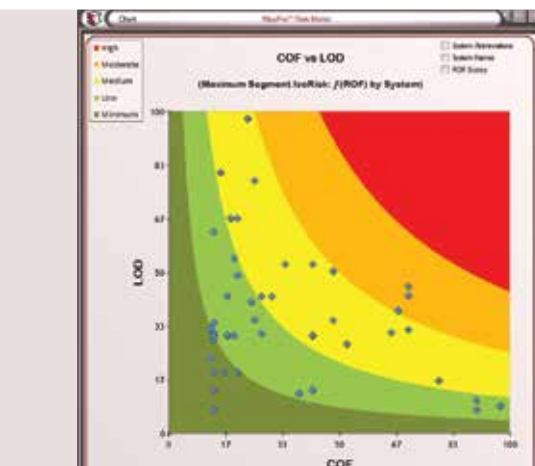
This **MAPPPro™** application complements the BPWorks™ Risk Ranking Module. Both BPWorks Risk and MAPPPro Risk can be run against the same database without impacting any information. MAPPPro Risk can be used by a site to prioritize inspections based on specialized concerns, whereas the results from the BPWorks™ Risk Ranking Module can be used for more standard comparisons of risk within a fleet or to other industry peers.

WHY USE MAPPPro RISK?

MAPPPro Risk provides the user the ability to configure the risk ranking algorithms to the unique design and operational experiences of the site. In addition, MAPPPro Risk considers all of the data types required in EPRI guideline 1016456 *Recommendations for an Effective Program to Control the Degradation of Buried Pipe*.



The risk ranking results can be viewed by each dynamically segmented portion of pipe or aggregated by line or by system. Data can be sorted and filtered to evaluate maximum, average or adjusted average (only values above the mean) for any element in the algorithm. Linear charts reveal the changing risk profile along the length of a line to help understand the locations of greatest risk. All data can be printed or exported to a spreadsheet for further manipulation.



As with all data in the BPWorks database, the risk information is linked to MAPProView™. Risk results can be viewed in various ways such as by algorithm element, system, or line. MAPProView files are easily viewable and don't require software licensing.

INTEGRATING TANK RISK

Companion tank risk algorithms are also available through MAPPro Tank. Tank risk results can be evaluated independently or integrated with pipe risk values for a more comprehensive system risk assessment.

MAPPPro™ TANK

CUSTOMIZED RISK ANALYSIS

Establishing the corrosion risk of buried and above ground storage tanks requires a different algorithm than is used for pipe. The design characteristics, likely corrosion mechanisms, inspection approaches and corrosion control measures are different than for pipe.

This **MAPPPro™** application provides the user interface, specialized risk algorithms and analysis tools to evaluate tanks, sumps and other non-pipe assets as part of the database.

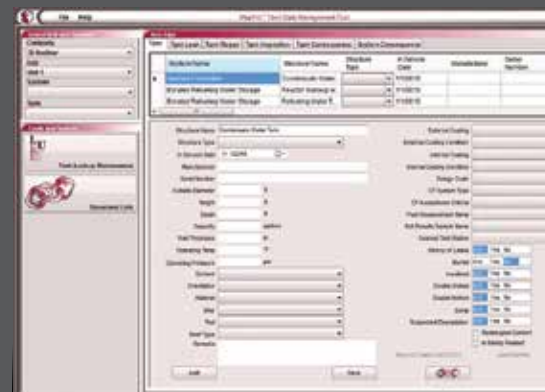
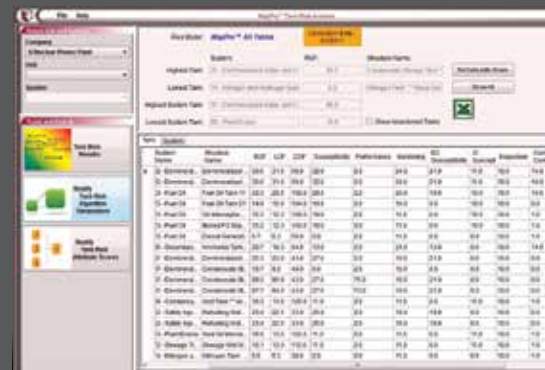
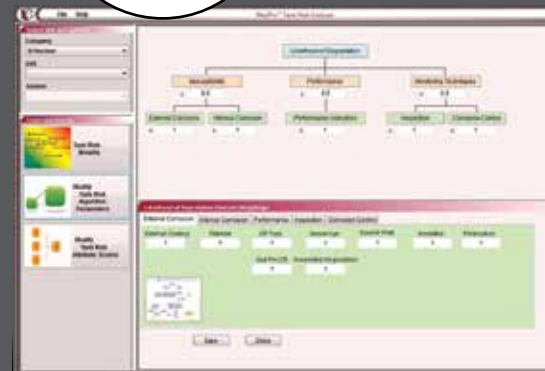
WHY USE MAPPro TANK?

NEI 09-14, *Guideline for the Management of Underground Piping and Tank Integrity* requires the inclusion of underground tanks that are outside of a building and below grade to be addressed in the site's integrity program if they are safety related or contain licensed material. The database includes a table to manage tank information. MAPPro Risk provides the user the ability to enter tank data and configure the risk ranking algorithms to the unique design and operational experiences of the site.

The risk ranking results can be viewed by tank or by system. Data can be sorted and filtered for any element in the algorithm. Tank risk results can be integrated and evaluated along with pipe risk data from MAPPro Risk to better understand overall system risk conditions. All data can be printed or exported to a spreadsheet for further manipulation.

VISUALIZING TANK RISK RESULTS IN MAPProView™

As with all data in the BPWorks database, the tank data input and risk result information can be linked to MAPProView™. Risk results can be viewed by algorithm element, system or individual tank. MAPProView files are easily viewable and don't require software licensing.



MAPPPro™ QUERY



WHAT IS MAPPro QUERY?

A Query is a request for information from a database. It is used to search a database for specific sets of conditions. The most flexible technique is Query By Example (QBE). In this method, the system presents a blank record and lets you specify the fields and values that define the query.

This **MAPPPro™** application links to the data in a BPWorks™ database and allows the user to search all information in the database based on custom needs. Multiple tables can be involved in the query.

USING MAPPro QUERY

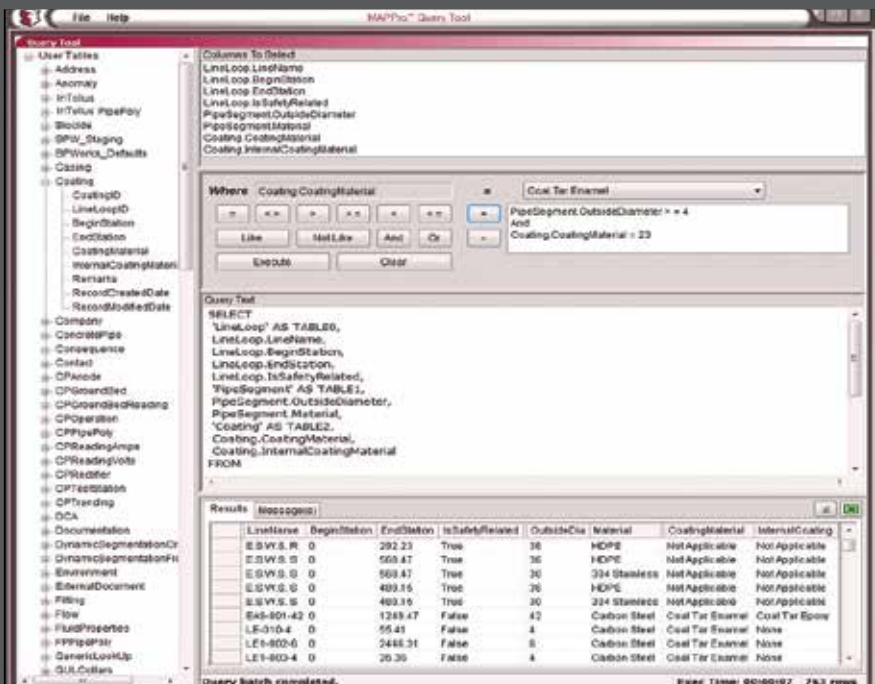
The method used in MAPPro Query for posing queries is to choose parameters from a menu. The database system presents a list of all tables, fields and parameters from which to select.

The user simply drags the field of interest from the left list into the top area to define what column appears in the grid below. You can further filter the results by dragging specific fields (i.e., CoatingMaterial from the Coating table) into the **Where** clause, then select the attribute of interest (coal tar enamel). To start the query, select the Execute button. Results appear in the grid below.

The query expression is displayed and can be copied to the clipboard and reused as part of future queries.

REPORTING RESULTS

Query results are displayed in a grid at the bottom of the form. Results can be printed or exported to a spreadsheet for additional manipulation. All fields from all tables used in the query are displayed and available as part of the results.



MAPPro™ CP & CP DESIGN SERVICES

EVALUATING CP MEASUREMENT DATA

Cathodic Protection (CP) data can be periodically collected at Test Stations and Rectifiers as part of a plant's routine periodic maintenance process or selectively as part of an inspection survey. The NACE Standard SP-0169, *Control of External Corrosion on Underground or Submerged Metallic Piping Systems*, provides evaluation criteria and guidance on the management of CP systems for effective corrosion control. The database provides tables for managing CP measurement and design data at test stations, rectifiers, ground beds and anodes.

This **MAPPro™** application provides the analysis tools to evaluate CP information and trends so informed decisions can be made to minimize the risk of external corrosion activity.

ANALYSIS & TRENDING CP INFORMATION

Analysis criteria can be applied to the data to highlight conditions that require attention. Charts are available to monitor changes in CP system performance over time, as well as observe broader performance issues around the site including On or Instant Off measurements below the -850 mV criteria or polarization values less than 100mV. Data and charts can be printed or exported to a spreadsheet for future manipulation. The latest improvement to MAPPro CP, the CP Dashboard, provides enhanced CP data tracking capabilities for License Renewal and other regulatory commitments."

IMPORTING CP RESULTS INTO BPWORKS™

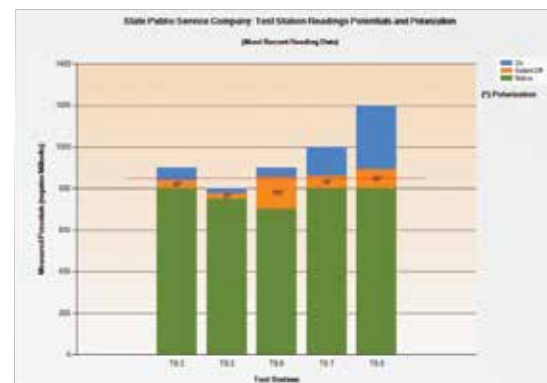
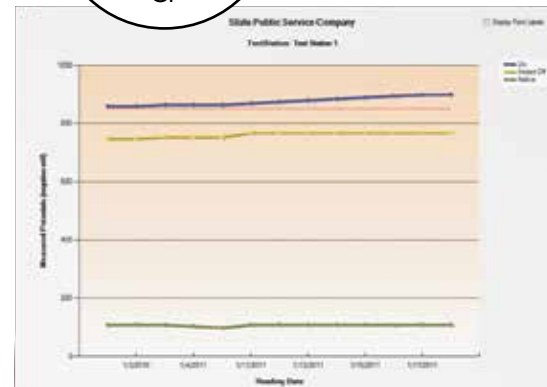
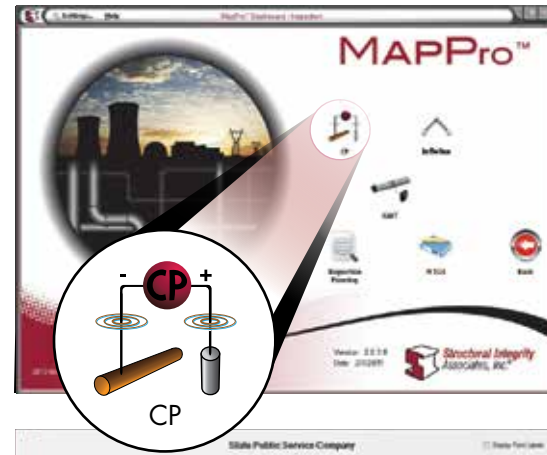
Structural Integrity has created a software process that imports CP measurement data from spreadsheets into your BPWorks database for easy evaluation. PDF reports and photos of the test stations and rectifiers can also be attached to the measurements for access in BPWorks or this MAPPro application. Blank spreadsheets or paper forms can be exported/printed for ease of data collection.

VISUALIZING CP RESULTS IN MAPProView™

As with all data in the BPWorks database, the CP information can be linked to MAPProView. CP values can be viewed in various ways such as by date, reading type (On, Instant Off, native) or by influence area to detect nearest pipe segments. Symbology colors change based on values above or below the NACE SP-0169 criteria.

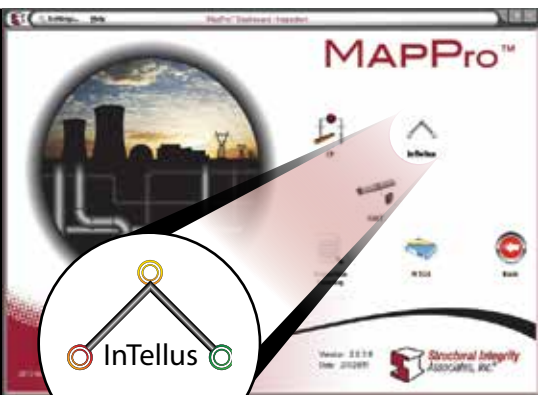
DOES YOUR PLANT NEED TO HAVE A CATHODIC PROTECTION (CP) SYSTEM?

The answer to this question should be YES, and more important is that it simply makes good sense to protect your critical buried piping assets. But it takes a special understanding of the complex power plant buried piping environment in order to design properly a new CP system or improve the performance of an existing plant CP system.



STRUCTURAL INTEGRITY IS THE BEST CHOICE FOR MEETING YOUR PLANT'S CP OBJECTIVES.
 SI's experienced engineers are NACE certified at the highest levels. This coupled with our InTellus experience and our understanding of the difficulties associated with corrosion control data collection in power plants means that a CP System designed by or recommendations for existing CP system enhancements made by SI will be certain to provide the best possible comprehensive plant corrosion control. You can always rely on us to handle your plant's CP projects professionally.

MAPPPro™ INTELLUS



WHAT IS InTellus?

InTellus is an electrical survey technique performed along the surface of the ground in close proximity to buried structures. InTellus inspections are used at plants both with and without cathodic protection systems. InTellus overcomes the challenges associated with coating condition and CP system effectiveness determinations for pipe in close proximity/networks, vertically stacked, and electrically connected. The survey results reveal information on the coating condition of buried pipe as well as the effectiveness of the applied cathodic protection at controlling external corrosion.

This **MAPPPro™** application provides users an interface to view InTellus inspection results in relation to buried structures, and a tool to evaluate the influence of rectifier outputs as part of the BPWorks™ 2 database.



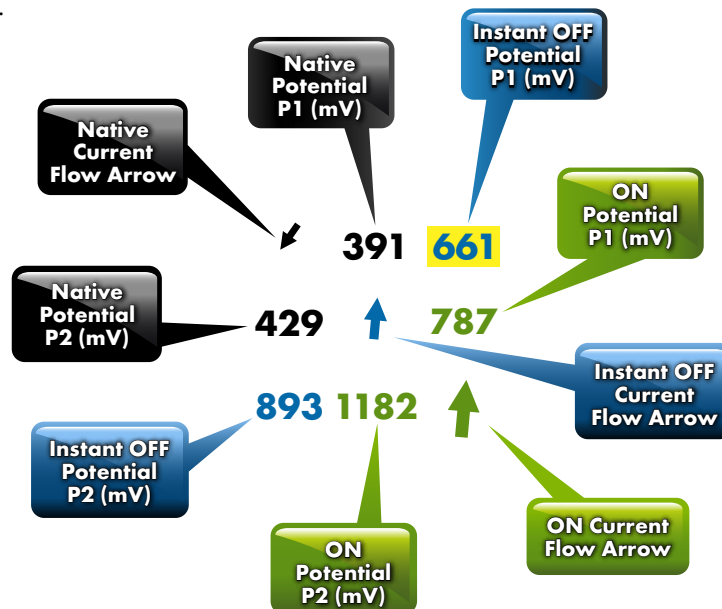
WHY USE InTellus?

InTellus information provides more than simple potential measurements around the plant. InTellus can be used to define the corrosion state and/or CP condition of all piping in the immediate vicinity of the InTellus test grid readings. In cases where coating degradation or insufficient cathodic protection is observed on critical piping, appropriate corrective actions can be taken. InTellus can also be used to evaluate the influence each rectifier has on the cathodic protection levels anywhere in the plant. This unique ability provides a valuable tool to the cathodic protection system engineer in making appropriate adjustments to rectifiers – providing optimum levels of current without over protecting, which can lead to accelerated coating degradation.



VISUALIZING INTELLUS DATA IN MAPProView™

As with all data in the BPWorks database, InTellus information can be linked to MAPProView™. MAPProView files are easily viewable and don't require software licensing.



INTELLUS SERVICES

InTellus SURVEYS - CATHODIC PROTECTION ASSESSMENTS FOR PLANT AND STATION PIPING ISSUES

Plants contain a complex network of underground piping that is connected to a copper grounding grid. Buried ferrous piping discharges DC current as an anode due to its connection to the more noble copper grounding grid that acts as the cathode of a corrosion cell; analogous to a battery. Structural Integrity can assess the potential for external corrosion of underground piping and structures without excavation by evaluating the coating condition and CP effectiveness

THE STRUCTURAL INTEGRITY SOLUTION

Structural Integrity's InTellus survey procedure is a modified CIS and DCVG technique that combines localized potential measurements with earth current voltage gradient measurements. The subsequent specialized interpretation produces meaningful information within a complex network of grounded piping that can be used to prioritize areas within the plant with the greatest potential for external degradation.

LOCALIZED POTENTIALS

The collection of many reference cell measurements in a plant will infer the corrosion condition(s) and/or CP state(s) of the buried piping and/or structures in the area of the reading(s)

EARTH CURRENT

DC earth current voltage gradients associated with corrosion cells or CP system operation can indicate the condition of a piping system's coating and/or the excessive collection of CP current on the station grounding grid. In a plant environment, it is important to know where any DC corrosion cell or CP current is going. When no CP system is present, the direction and magnitude of any native corrosion cell currents are observed. If CP rectifiers are cycled "ON" and "OFF", the migration of CP current around the plant can be understood.

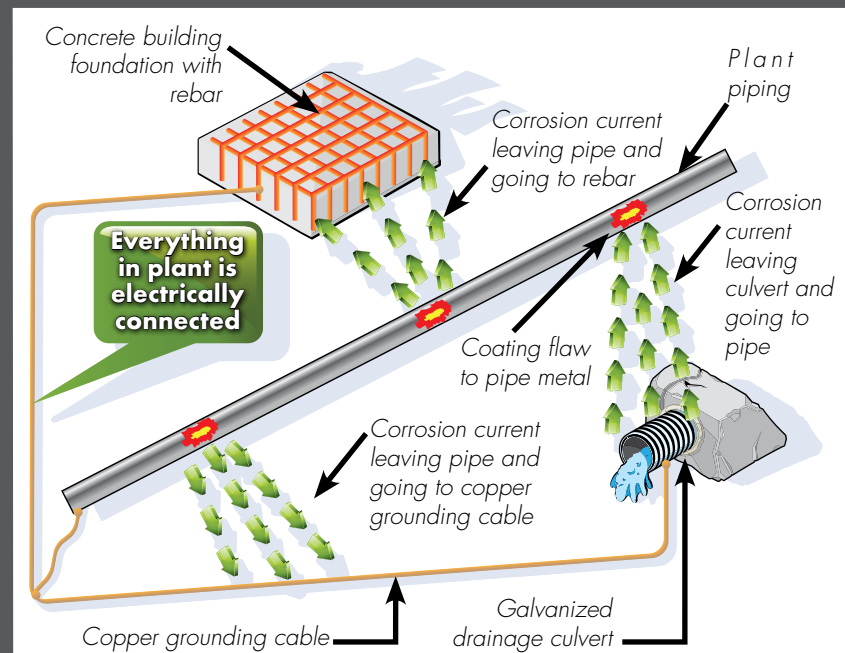
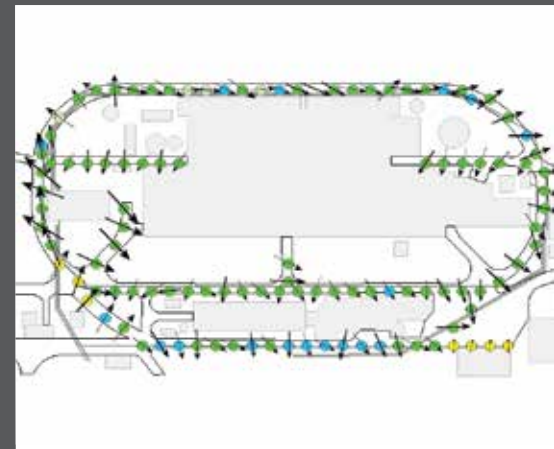
RESULTS

The integration of InTellus magnitude and direction vectors provides an indication of any aggressive corrosion cells, and a clear picture of a CP system's effectiveness. The InTellus survey will also help define areas of piping with coating degradation, as these areas will tend to collect more of the CP current.

The InTellus survey is the perfect choice for plants with and without CP systems.

DATA INTERPRETATION

Structural Integrity's state-of-the-art database visualization tool. MAPProView™ is a graphical analysis tool for viewing and analyzing the results of the InTellus survey in relation to the underground structures, grounding grid and other inspection information (e.g., GWUT, visual, UT, leaks, etc.). This ensures easy interpretation of possible corrosion cell locations and CP system effectiveness.



MAPPro™ GWT



INTEGRATING GUIDE WAVE INSPECTION RESULTS INTO BPWorks™

Guided Wave Testing (GWT) is a recognized technology for the indirect inspection of buried pipe for metal loss from a limited access point. The results can be used to confirm that significant corrosion has not occurred or to direct further inspections at areas of greatest concern. GWT inspections can be an integral tool in an overall buried pipe inspection program.

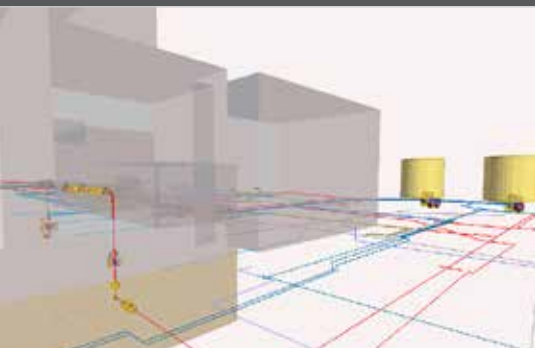
This **MAPPro™** application allows plants to manage and visualize all GWT information available for export from the **GUL Wavemaker™** software. The **Collection** tab displays setup characteristics, signal amplitude statistics and analysis parameters while the **Report** tab provides the feature detail information. Storing GWT data electronically will enhance the site's ability to use this data in the future.



New and historical information for both buried and above ground GWT inspection data can be managed in this application.

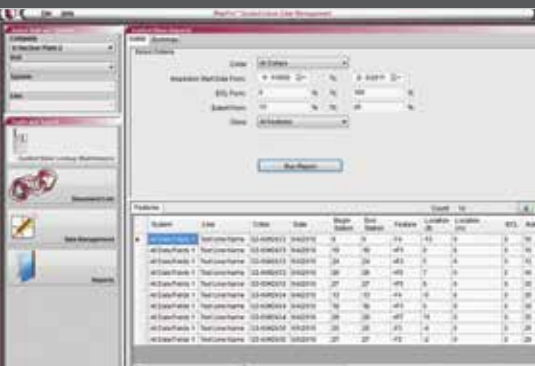
IMPORTING GWT RESULTS INTO BPWorks

Structural Integrity has created a software process that extracts inspection pre-assessment information from your **BPWorks™** database (i.e., line name, diameter, coating type, etc.), exports all GWT inspection result information collected using the **GUL Wavemaker™** software, and then imports the GWT data into tables in the **BPWorks™** database. In addition to viewing the GWT results electronically, the data is available for the risk model to use when assessing the impact of the inspection. PDF reports and inspection photos can also be attached to the inspection results for access in **BPWorks** or this **MAPPro** application.



VISUALIZING GWT RESULTS IN MAPProView™

As with all data in the **BPWorks** database, the GWT information can be linked to **MAPProView**. GWT inspection results can be viewed in various ways such as by feature, system, line or inspection report. Photos, the analysis signal waveform, or the entire vendor inspection report can be hyperlinked to the GWT collar location as a PDF file for rapid retrieval by any user at the plant. **MAPProView** files are easily viewable and don't require software licensing.



GWT gPIMS® INSTALLATION & MONITORING

WHAT IS gPIMS?

In difficult to access piping configurations where access is challenging and costly, or where the need to monitor the rate of damage exists, Guided Wave Testing (GWT) via gPIMS (Permanently Installed Monitoring System) is a corrosion monitoring option. The latest in enhanced GWT sensor technology, manufactured by Guided Ultrasonics Ltd. (GUL), can be installed and buried. The gPIMS are easily accessed at any time via the above ground connection box, which has internal electronics that store the test parameters such as pipe size, inspection parameters and the file reference for the previous test result to allow direct comparison.

INSTALLATION PROCESS

Structural Integrity has trained personnel that can perform the installation, testing, and inspection process. The process requires initial testing using traditional portable GWT collars and ultrasonic thickness testing to establish the current condition of the pipe. The gPIMS collar is installed, followed by prebackfill tests and measurement to confirm the functionality of the sensor. Approximately 30 days after reburial, another measurement is collected (called the baseline test) and the gPIMS connector box is programmed for future tests.

KEY FEATURES

Permanently installed GWT sensors provide several unique inspection benefits:

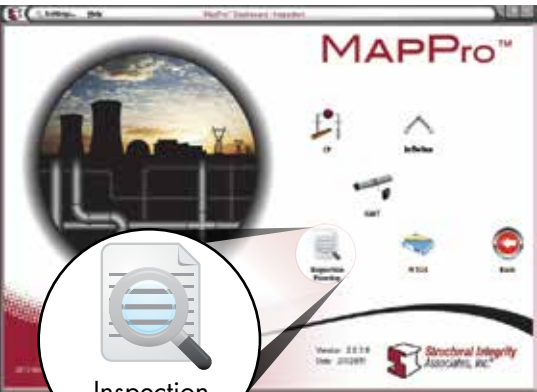
- **Ease of Access** – Surface mounted connection points mean that periodic testing is simple and low cost.
- **Improved Sensitivity** – Results can be easily compared to previous tests to detect small (<1%) cross sectional changes in the condition of the pipe.
- **Trending** – Measuring with the same sensors at a fixed position simplifies the comparison of measurements, permitting degradation rates to be established.

VISUALIZING GWT RESULTS IN MAPProView™

We can also integrate the GWT location and data into a site's BPWorks™ database or into MAPProView to facilitate the review and trending of feature information.



MAPPro™ INSPECTION PLANNING



NEI 09-14, *Guideline for the Management of Underground Piping and Tank Integrity*, contains an element requiring development of an inspection plan to provide reasonable assurance of buried pipe integrity. There are a wide variety of inspection technologies on the market. Each was designed to detect a specific corrosion threat for specific materials under specific geometric or environmental conditions. No one inspection method will produce robust, practical inspection information for all applications.

MAPPro™ Inspection Planning application links to the design, operation and environmental data in a BPWorks™ database, compares the pipe segment conditions to the technical capability specifications for each method, and then yields guidance on candidate methods that can be used to assess the condition of the pipe. This can provide valuable guidance to a buried pipe engineer with limited inspection selection experience or consistent decision making practices within a fleet.

BENEFITS OF MAPPro INSPECTION PLANNING

Generic bounding conditions for each inspection technology can be reviewed by the user and adjusted based on prior experience. The user can establish a priority preference for each inspection technology, such that when multiple inspection options are viable, the preferred method is selected and scheduled for inspection.

If integrated with the MAPPro Risk module, the inspection methods can be further prioritized, according to the calculated risk ranking results, to establish a risk-prioritized inspection schedule. Inspection date range criteria can be designated based on relative percentages score (i.e., highest 10%, top 25%, etc.) or a fixed risk per period (i.e., year, 3 years, etc.).

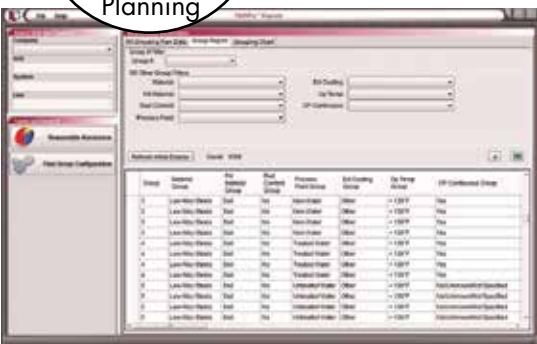
Existing functionality within BPWorks allows for the nomination of future inspection methods and inspection dates. This information can be extracted and used as part of a workflow management process.

REASONABLE ASSURANCE GROUPING

An inspection optimization tool exists that allow for automatically creating data groupings consistent with the Reasonable Assurance guidance document. These reports and charts can be filter for NEI 09-14 Revision 0 or 1 scope, or can be modified to aggregate or discount grouping criteria.

VISUALIZING INSPECTION DATA IN MAPProView™

As with all data in the BPWorks database, Inspection Planning information can be linked to MAPProView™. MAPProView files are easily viewable and don't require software licensing.



MAPPPro™ N513

ENGINEERING PRE-INSPECTION EVALUATION

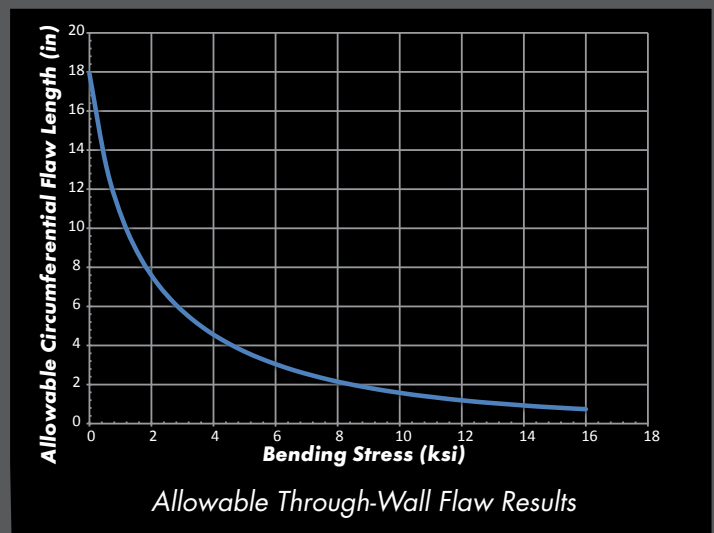
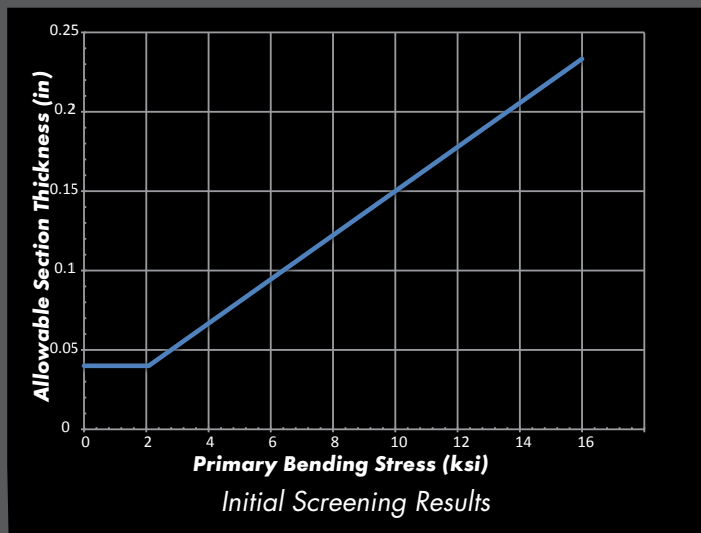
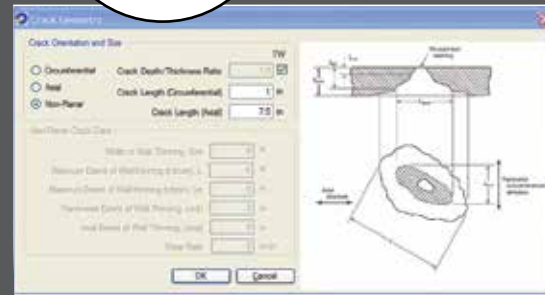
Prior to excavations and inspection as part of an overall buried pipe program, SI recommends that engineering evaluations be conducted to determine the flaw tolerance of the buried piping to be inspected. This allows the owner the opportunity to take actions, such as re-evaluation of design basis documents, without the added pressure of being in an LCO (Limiting Conditions for Operation) which could force an unplanned outage.

Our MAPPPro™ N513 module performs this pre-inspection evaluation by applying the principles of the ASME Code Case N-513-3 to the existing information contained in the BPWorks™ database.

MAPPPro N513

The MAPPPro N513 Module works with the **MAPPPro™ family of Buried Pipe Applications** and can perform flaw tolerance estimations for any section of straight pipe in the BPWorks™ database. There are two levels of analysis:

1. An initial screening based on both the hoop and axial allowable stresses,
2. A more detailed analysis that provides estimated allowable through-wall flaw dimensions. Because the BPWorks database does not currently contain applied bending loads, the analysis results are presented as a function of bending stress.



MAPPro™ WELL

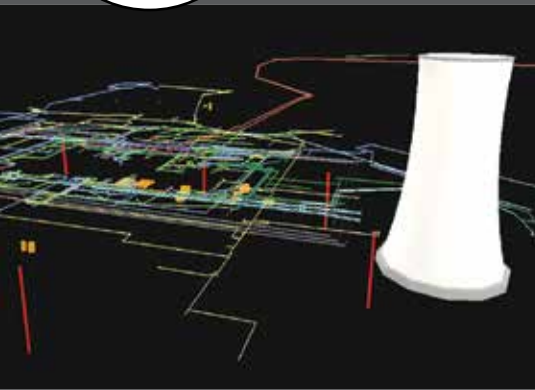


INTEGRATING WELL AND PIPING DATA

The NEI 07-07 Groundwater Initiative led to the need for plants to monitor for the presence of tritium in the environment; avoiding any potential to compromise the groundwater, surface water or other drinking water sources.

This MAPPro application allows plants to manage and visualize tritium monitoring well data in the same SQL database that is used for buried pipe integrity. As such, the measured well data can be directly related to buried pipe information to allow the user to identify: nearest pipe to a well, nearest pipe with licensed material, wells with increasing concentration, etc.

The database information is linked to the site's MAPProView software. This allows the information to be viewed relative to buildings, piping, tanks and other structures. Data symbology is designed to change colors at predetermined concentration thresholds to alert the user of abnormal conditions.



Reading Date	Tritium Conc	Analyzed By	Remarks	Record Created	Last Modified
1/27/2011	0				

Groundwater table and soil taxonomy information can be overlaid on to the display for evaluation. Time-based trending can also be evaluated.

MAPP^{ro}™ CABLE

CABLE AGING MANAGEMENT

Electrical cables are a critical part of industrial facility and power generation infrastructure. The cables power the equipment and provide sensing information and control signals. For nuclear plant first and second license renewal, cable aging management remains one of the top 3 long term regulatory issues to manage, along with piping/vessels and concrete/structures. As with other long-lived passive components, cable aging needs to be managed to help ensure reliable performance for the life of the plant. The likelihood of failure increases the longer cable systems have been in service.

Cable failures have a variety of causes, including exposure to electrical transients, latent installation defects, or adverse local environmental conditions during operation. Some cables age relatively rapidly because of severe environments or service conditions. Independent of the mechanism, understanding and managing the data necessary to perform a rigorous engineering assessment and targeting the most susceptible cables is critical to success.

WHY CONSIDER A CABLE AGING SOFTWARE ASSESSMENT TOOL?

EPRI recommends that plants have a cable aging management program. Most later license renewal programs require a cable aging management program, which includes determining the scope of the program and identifying the assessment strategy. The program scope should include both medium and low voltage cables. Current industry practices focus on inspection of cables approximately every 6 years for medium voltage cables, with sampling strategies used for low voltage cables.

MAPP^{ro} CABLE

The MAPP^{ro} Cable Module is part of the MAPP^{ro}™ family of Applications and can capture data into the MAPP^{ro} industry standard database platform. Elements of the database include cable screening, risk ranking, service environment, historical performance and inspection/test results.

This application considers the guidance provided in NUREG-1801, Generic Aging Lessons Learned (GALL) Report Section XI.E¹ and EPRI Plant Support Engineering guides on Low Voltage² and Medium Voltage^{3,4} cable aging management programs. The risk module considers industry inspection experience and NRC requirements⁵ for information to be included in cable aging management programs.

WHY USE MAPP^{ro} CABLE?

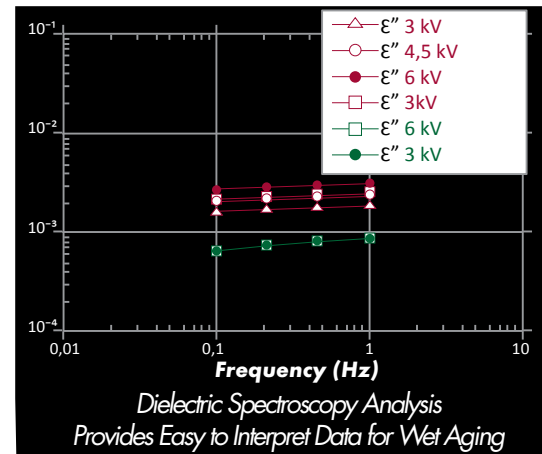
MAPP^{ro} CABLE allows users to manage information about low and medium voltage cables as part of a Cable Aging Management program. Data can be linked for viewing in MAPP^{ro}View™. Risk ranking results can be viewed and data can be sorted and filtered for any element in the risk algorithm. Cable risk results can be integrated and evaluated along with testing results to better understand overall system risk conditions and recommended test interval. All data can be printed or exported to a spreadsheet for further manipulation.

THE STRUCTURAL INTEGRITY SOLUTION

SI core competencies for an integrated solution to cable system aging management include development of a comprehensive cable aging management program and a database that includes all relevant attributes for program management (including the ability to risk rank and prioritize cables for inspection).



Failed Medium Voltage Splice Assembly



Dielectric Spectroscopy Analysis
Provides Easy to Interpret Data for Wet Aging

1. NUREG 1801, *Generic Aging Lessons Learned (GALL) Report*
2. EPRI 1020804 – *Aging Management Program Development Guidance for AC and DC Low-Voltage Power Cable Systems for Nuclear Power Plants*
3. EPRI 3002000557 – *Aging Management Program Guidance for Medium-Voltage Cable Systems for Nuclear Power Plants*
4. EPRI 1021070 – *Medium Voltage Cable Aging Management Guide*
5. NUREG/CR-7000, *Essential Elements of an Electric Cable Condition Monitoring Program*

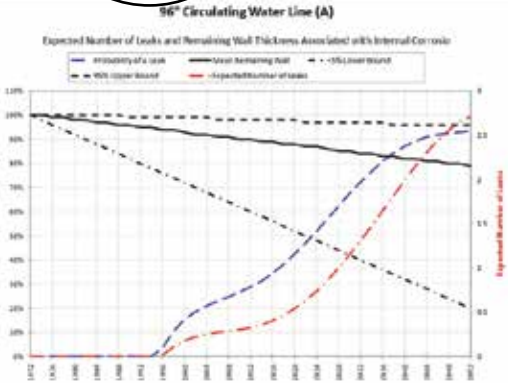
MAPPPro™ LCM



WHAT IS AN LCM ANALYSIS?

The objective of a Life Cycle Management (LCM) assessment is to provide the plant's technical management with analysis and insight to assure that the remaining life of the buried components meet operational needs. The results of an LCM assessment can be used to optimize the overall life of these systems as part of a comprehensive asset management plan required by NEI 09-14, *Guideline for the Management of Underground Piping and Tank Integrity*.

This future **MAPPPro™** application links to the material, diameter, length, fluid property and operating data in a BPWorks™ database. The data is then processed through Structural Integrity's ACCORDION internal corrosion prediction model generating probabilistic leak evolution and remaining wall thickness information.



BENEFITS OF MAPPPro LCM

MAPPPro LCM allows you to quickly generate the information necessary as part of a Life Cycle Management evaluation. This analysis is a useful tool to review existing buried assets by modeling the piping systems to predict when leaks are most likely to occur. The results can be used to suggest improved maintenance strategies to better assure that the remaining life of the buried assets meets economic and operational needs. When combined with MAPPPro Risk, ranking results can be used to select those components with the highest risk of failure for evaluation.

MAPPPro LCM is applicable to water-based systems in carbon steel pipe without internal coatings or linings. The influence of water quality and characteristics, biocide addition practices, potential for microbially-induced corrosion, (MIC) and corrosion inhibitor treatment is addressed in the model.

INTEGRATION WITH MAPPPro INSPECTION PLANNING & MAPPProView

The leak probability results can be integrated with the MAPPPro Inspection Planning application to account for the internal corrosion leak potential of a system.

As with all data in the BPWorks database, MAPPPro LCM results can be linked to MAPPProView™. MAPPProView files are easily viewable and don't require software licensing.

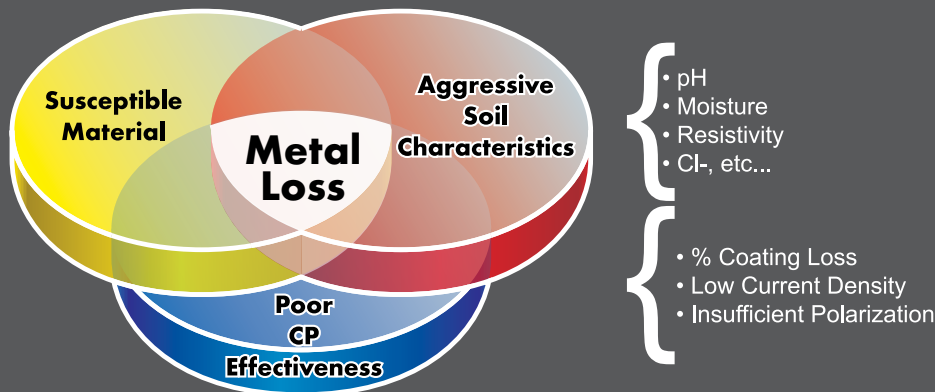


MAPPro™ SOIL

IMPORTANCE OF SOIL ANALYSIS

The external corrosion susceptibility of buried piping varies dramatically as a function of several variables, including soil chemistry, particle size distribution, and applied cathodic protection. Understanding the environment around buried structures allows a corrosion engineer to evaluate the potential rate of metal loss in the event that the corrosion controls fail (i.e., coatings or cathodic protection systems). Knowledge of the soil corrosivity can be used to prioritize and select inspections in support of a buried piping program, as well as aids in the design of new or improved cathodic protection systems.

NUREG-1801 Section XI.M41 revision 2 requires the consideration of soil characteristics as part of the license renewal process.



This **MAPPro™** application links to the soil and cathodic protection data in a **BPWorks™** database and uses Structural Integrity's **SoilPro™** external corrosion prediction model to develop a maximum anticipated pitting rate (mils/yr or mm/yr).

SoilPro™

Soil corrosivity is a function of many variables, including dissolved salt content, particle size distribution, resistivity, and applied potential. We developed **SoilPro** based on a thorough review of the published literature and over 130,000 regression analyses on 42 datasets representing a variety of conditions around the world.

SoilPro is a soil corrosiveness model that:

- Provides quantitative estimates of corrosion rates, which are useful for predicting remaining life or prioritizing locations for direct examination
- Considers multiple soil parameters to address the complex interaction of various soil attributes
- Provides a means to illustrate the beneficial effect of cathodic polarization on the estimated corrosion rate

REPORTING RESULTS

This application will calculate the effective corrosion rate of soil and record the values as part of the soil record in **BPWorks 2**. Once calculated, the results can be used as part of **MAPPro Risk** displayed in **MAPProView™**.

HDPE EXAMINATION



INDUSTRY ISSUE

Metal is the ASME accepted and predominantly used material for piping and other pressure retaining components used in the nuclear industry. However, the metal piping used to transport water is typically prone to corrosion, fouling, rusting and microbiological attack which requires continual maintenance, repair, chemical treatment, and replacement of degraded piping.

SOLUTION

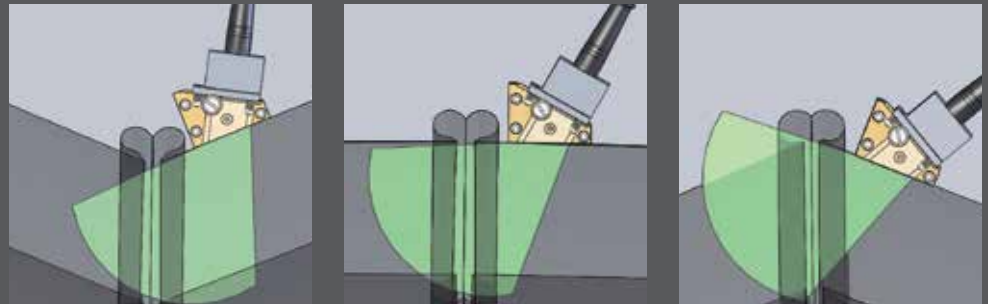
To eliminate the challenges associated with maintaining metal piping, the nuclear power industry is now selectively using High-Density Polyethylene (HDPE) piping for non-safety and safety related applications. HDPE piping is preferred as it does not rust, rot, corrode, or support biological growth. In addition, the use of the HDPE piping in raw water applications ensures long term structural integrity and water flow reliability with minimal of maintenance.

VOLUMETRIC EXAMINATION

HDPE piping systems are made of multiple straight and mitered butt-fusion joints. To ensure the high integrity fusion including the absence of subsurface fusion defects, an Ultrasonic Phased Array examination technique has been developed.

Phased Array has advantages over other examination methods:

- Uses a sweep of angles, which greatly increases the probability of detection of defects.
- When optimized, provides coverage of nearly 100% of the fused joint.
- Only requires access from one side of the joint at a time.
- Data represented in side, top, end, and cylindrical-side views, which can be viewed during "live" scanning, or defined during analysis after the data has been recorded.



The technique developed by Structural Integrity Associates, Inc. is optimized to examine up to 7 inch wall-thickness.

FIELD EXAMINATION

Structural Integrity's recommended field practice is to perform fully-encoded and recorded scans that are saved as permanent record. This provides one continuous scan (which can be broken into segments), with uniform probe positioning, while recording indication locations that are saved as permanent record.

MAPPro™ TECHNICAL RESOURCES

WEBINARS

- Management of Aging Buried Nuclear Piping
- Cathodic Protection: Application & Testing in Plants
- Cathodic Protection Principles

PUBLICATIONS

Smart, A., Jensen, A, Biagiotti, S.F., and E. Elder,
Methodology for Surveying Buried Plant Piping for Coating Condition and CP Effectiveness,
NACE CORROSION/2011, Paper No. 11181, Houston, TX, March 15, 2011.

Biagiotti, S.F., Biles, S.R., and C.E. Chaney,
Using Soil Analysis and Corrosion Rate Modeling to Support ECDA and Integrity Management of Pipelines and Buried Plant Piping,
NACE CORROSION/2010, Paper No. 10059, San Antonio, TX, March 16, 2010.

PRESENTATIONS

Licina, G., *Development of a Corporate Standard for Cathodic Protection (CP) as a Long-Term Corrosion Mitigation Strategy for Buried Pipe*,
EPRI BPIG Conference, Palm Coast, FL, Feb 15, 2011.

McManus, S.A., *Nuclear Buried Pipe Initial Industry Trends Utilizing BPWorks 2*,
EPRI BPIG Conference, Palm Coast, FL, Feb 15, 2011.

Barta, G., Jensen, A., and S.F. Biagiotti, *Using (Area Potential Earth Current) for Buried Pipe Inspections*,
EPRI BPIG Conference, Atlanta, GA, July 13, 2010.

Biagiotti, S.F., *Buried Piping Programs in Nuclear Plants*,
NACE CORROSION/2010 TG-404, San Antonio, TX, March 16, 2010.

Biagiotti, S.F., *The Importance of Mitigation and Monitoring for Buried Piping Plant Sites*,
EPRI BPIG Conference, Palm Coast, FL, Feb 16, 2010.

Biagiotti, S.F., *Direct Assessments of Buried Piping at Nuclear Facilities: Lessons Learned*,
EPRI BPIG Conference, Golden, CO, July 2009.

Biagiotti, S.F., *Integrating Soils Data with Over-the-Line Surveys for Ranking Direct Examination Sites*,
EPRI BPIG Conference, Golden, CO, July 14, 2009.

Biagiotti, S.F. and K.R. Rach, *Direct Assessment in Plants: Criteria, Challenges, and Monitoring Considerations*,
EPRI BPIG Conference, Palm Coast, FL, Feb 10, 2009.

Biagiotti, S.F., *Underground Pipe & Tank Management Programs*,
EPRI BPIG Conference, Palm Coast, FL, Feb 10, 2009.





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