GAS SAFETY MARGIN
INFORMED BY RECORDS VERIFICATION AND MAXIMUM ALLOWABLE OPERATING PRESSURE VALIDATION

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1 Background

1.1 Company Overview

Pacific Gas and Electric Company (PG&E), incorporated in California in 1905, is currently one of the largest combination natural gas and electric utilities in the United States (US). The company provides natural gas and electric service to approximately 15 million people throughout a 70,000-square-mile service area in Northern and Central California as shown in Figure 1 below. PG&E's gas transmission system contains approximately 5,800 miles of gas transmission pipeline as defined by 49 CFR §192.3 and a total of approximately 6,750 miles of total gas transmission pipelines as defined by PG&E that adopts the definition of 49 CFR §192.3 and also includes those pipelines with an operating pressure greater than 60 psig. PG&E owns and operates approximately 42,000 miles of gas distribution pipe (60 psig or less) and serves 4.3 million natural gas customer accounts (1/20th of all US Gas Consumers[1]), and delivering 970 BCF/year (2.6 BCF/daily average).

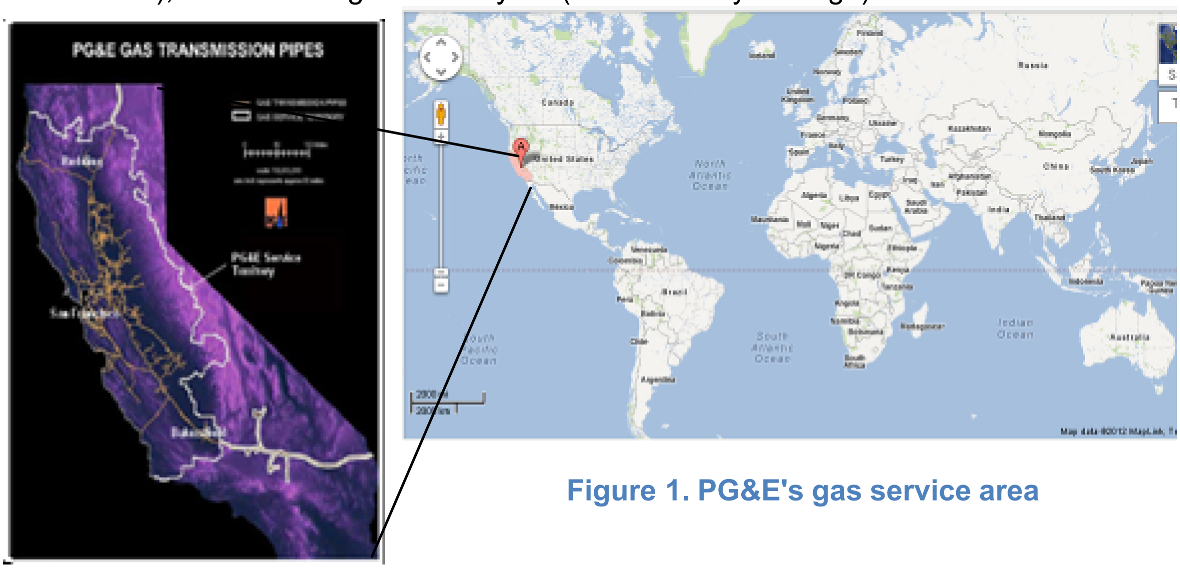


Figure 1. PG&E's gas service area

Approximately 67% of PG&E's gas transmission system's pipelines were installed prior to1970 and 30% of the pipeline miles are within Class Location 3 and 4 and High Consequence Areas (HCAs) in Class Location 1 and 2.

PG&E's culture and some of its operational practices came into scrutiny and question after a number of accidents occurred. In particular, a September 2010 pipeline explosion in San Bruno, California resulted in eight deaths, numerous injuries, property damage and harm to PG&E's reputation.

This paper briefly reviews the San Bruno accident and the actions taken—specifically around Maximum Allowable Operating Pressure (MAOP) validation and records verification--since that time. With the total miles covered, the level of detail and quality oversight required, and compressed time schedule for this work, PG&E has gained a significant amount of experience in this work and this is believed to represent an unprecedented effort for a United States utility. Following are some valuable lessons about conducting MAOP validation and records verification work, and some recommendations on how to build an asset management program with traceable, verifiable and complete data.

[1] Based on total US Gas Consumers compiled by the US Energy Information Administration http://38.96.246.204/dnav/ng/ng_cons_num_dcu_nus_a.htm

1.2 Incident Summary and Regulatory Response

On Sept 9, 2010, a PG&E 30-inch-diameter natural gas transmission pipeline (Line 132) ruptured in a residential area approximately 10 miles south of San Francisco, in the city of San Bruno, California. The accident killed eight people and injured 58 more; affected 108 houses, 38 of which were destroyed and 17 of which were severely to moderately damaged; in addition, 74 vehicles were damaged or destroyed.

The data that PG&E submitted to the National Transportation Safety Board (NTSB)—the federal agency responsible for investigating accidents of this nature—from PG&E's geographic information system (GIS) database on transmission pipeline characteristics and operations identified the ruptured segment of pipeline as seamless. In fact, the segment contained pipe with various types of manufacturing longitudinal seam welds. Because of this incongruity, the NTSB issued urgent safety recommendations to PG&E on January 3, 2011, with respect to searching for records and validating the MAOP of its gas transmission pipelines in Class 3 and Class 4 locations and Class 1 and 2 ("HCAs").

1. P-10-2: "Aggressively and diligently search for all as-built drawings, alignment sheets, and all design, construction, inspection, testing, maintenance, and other related records…for PG&E Company natural gas transmission lines in class 3 and class 4 locations and class 1 and class 2 HCAs that have not had a MAOP established through prior hydrostatic testing. These records should be traceable, verifiable, and complete.
2. P-10-3: "Use the traceable, verifiable, and complete records….to determine the valid MAOP, based on the weakest section of the pipeline or component to ensure safe operation…"
3. P-10-4: "If you are unable to comply with Safety Recommendations P-10-2 and P-10-3 to accurately determine the MAOP…determine the MAOP with a spike test followed by a hydrostatic pressure test.

Also, in January 2011, US Senators Dianne Feinstein and Barbara Boxer introduced a pipeline safety bill. Of its six provisions, one required that gas operators establish complete records of pipeline components in order to verify and validate the MAOP of each component. Additionally, the U.S. Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) included records verification and MAOP validation in its Advanced Notice of Proposed Rulemaking, shortly thereafter.

In October 2011, the American Gas Association (AGA) issued a whitepaper containing industry guidance on records review for re-affirming Transmission pipeline MAOPs that included the following:

> "Operators may discover that some of the original records used to establish pipeline MAOP may now be missing or judged to be incomplete by today's standards. Due to mergers and acquisitions, some pipelines changed ownership without historical records being shared or retained. The current federal requirements to conduct a post construction pressure test, and to keep records of that pressure test, came into existence in 1970 with the inception of the federal pipeline safety code. Although federal regulations were not in place prior to 1970, most pipeline operators installed pipelines and established a pipeline's MAOP under the American Standards Association (ASA) B31.1 standard (1935-51), the American Society for Testing and Materials (ASTM) B31.8 standard (1952 and after) or individual company standards, which were largely based upon the foundation of the ASA/ASME standards. In addition, a number of states had established pipeline safety regulations prior to federal regulation. When the federal pipeline safety code came into existence, DOT recognized that historical operating pressure documentation might be the only record

available for operators to establish MAOP, even if a pipeline had been tested according to the ASA/ASME standards in place at the time of installation."

In January, 2012, The Pipeline Safety, Regulatory Certainty, and Job Creation Act of 2011 was signed by President Barack Obama, that includes a provision requiring pipeline owners and operators to assess historical records and verify the MAOP in populated or certain HCAs. This means that PHMSA is considering the inclusion of this requirement as part of the federal code.

Based on these events, natural gas transmission operators throughout the world should be keenly interested in records verification and MAOP validation as a foundational element to operating gas transmission pipeline systems. PG&E's goal from this effort and other similar initiatives is to enable a robust integrity management program with access to real-time, traceable, verifiable and complete information that is accurate and reliable and facilitates safe operations and prudent decision making during emergency response.

2 Aims

2.1 Immediate Project Aims

1. Cooperate fully with the Jan 3, 2011, NTSB Safety Recommendations and the subsequent California Public Utilities Commission (CPUC) order
2. Ensure that PG&E’s pipelines are operating at safe MAOPs, and that the records accurately reflect pipeline features.
    a. Use the “traceable, verifiable, and complete” records to determine the valid MAOP, based on the weakest section of the pipeline or component, for all gas transmission lines in class 3 and 4 locations and class 1 and class 2 HCA’s that have not had a MAOP established through prior strength testing (705 miles)
    b. Expand the same level of rigorous investigation and analysis to the entire gas transmission system (approximately 6,750 miles)
3. Restore public confidence in the safety and integrity of PG&E’s natural gas transmission system

2.2 Additional Project Aims

Additionally, PG&E will be leveraging the data collected through this effort to establish the ability to integrate critical gas transmission information into a component based GIS and enhance data capabilities to enable sound engineering and integrity management decisions. PG&E believes that a more robust integrity management program can be established based on better component level information for in service gas assets. The MAOP validation effort addresses the need for accurate identification of assets with traceable, verifiable, and complete information. In combination with the operating and maintenance data associated with the condition of these assets, PG&E will be able to employ a more proactive maintenance model for its gas assets. This is similar to how other industries, such as aerospace and nuclear industries, leverage Reliability Centred Maintenance (RCM) models, where safety and reliability have played a critical role in shaping operational and maintenance models.

RCM is a process used to identify potential corrective actions to ensure that any and all physical assets continue to perform in the required manner. Asset intelligence will enable PG&E to better understand the specific characteristics of in service assets and to align the maintenance efforts based on the critical nature of the respective asset. For example, accurate systematic understanding of when and where a particular asset component was first installed and last inspected or repaired, gas operators can better incorporate prioritized maintenance and inspection activities for that asset component to reduce the risk of component malfunction or failure. The result of such improvements is safer more reliable service for customers and improved public and employee safety.

Figure 2 shows an illustration of RCM in use.

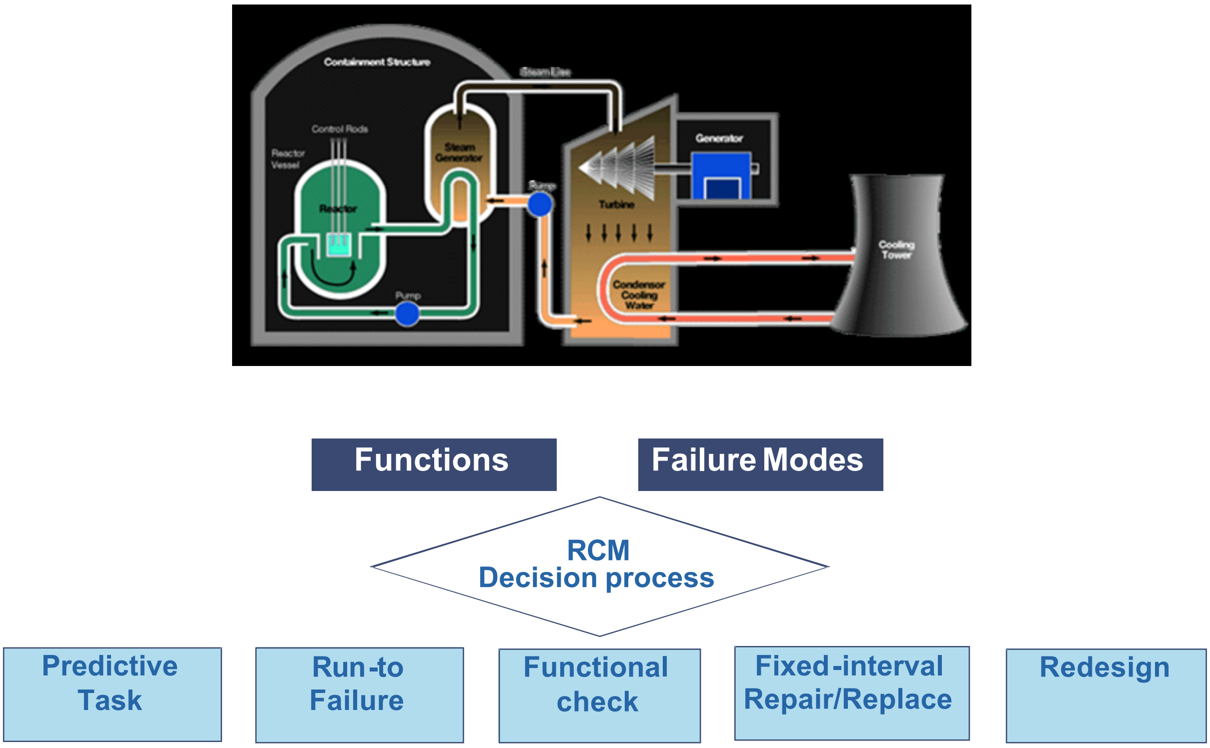


Figure 2. RCM Decision Process used in managing asset failure through the full life cycle of assets

Figure 3 below shows a Process flow for RCM:

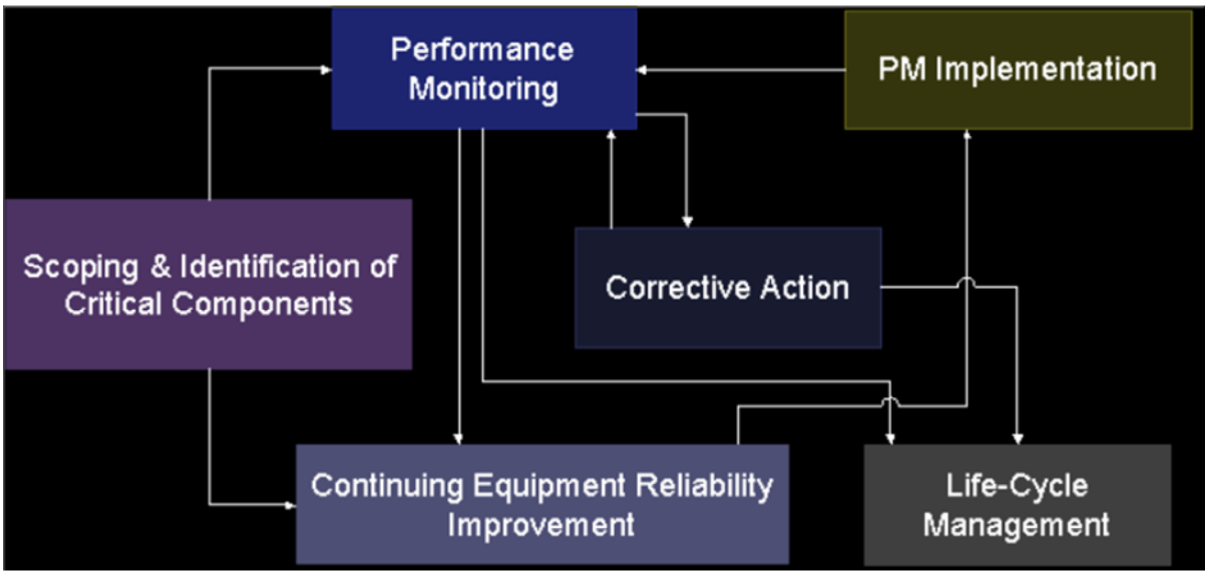


Figure 3. Overview of a simplified Equipment or Asset Reliability Process defined originally by Institute of Nuclear Power Operators (INPO AP-913) as an industry umbrella program consisting of six main elements of an effective maintenance program

PG&E's vision is to be the natural gas industry leader in data collection, validation and retention by leveraging technology to ensure traceable, verifiable and complete asset information is available real time to support critical business needs for PG&E's natural gas transmission and distribution assets.

3 Methods

3.1 Project Overview

The NTSB Safety Recommendations and the subsequent CPUC order resulted in PG&E initiating the Records Verification and MAOP Validation project with a focused effort on approximately 1,805 miles of HCA pipeline in PG&E's transmission system. However, PG&E expanded the scope of this project to include the entire transmission pipeline network consisting of 6,750 miles, shortly thereafter.

At a high level, the project consists of three phases with an end goal of validating the MAOP for all sections of PG&E's gas transmission pipelines located within California. The first 2 phases address the CPUC order and the third phase includes the remainder of the transmission pipeline system.

<u>Phase 1: Strength test records verification</u>
The objective of the first phase was to identify the pipeline segments without prior strength tests. This was accomplished by collecting and reviewing records for 1,805 miles of HCA pipelines to determine whether PG&E had traceable, verifiable, and complete records of the following:

1. Pressure tests on HCA transmission pipelines
2. Pipeline's highest actual operating pressure from July 1, 1965 through June 30, 1970, for HCA pipelines installed prior to 1970. While these records were located as part of this phase, the associated pipelines were included in phase 2, as these records did not constitute a strength test record.

<u>Phase 2: MAOP Validation of HCA pipeline segments without prior strength test</u>
Perform MAOP Validation of HCA pipeline segments for all class 3 and 4, and class 1 and 2 HCA transmission pipelines (approximately 705 miles) without prior strength tests as referenced in the Jan 3, 2011 NTSB recommendations P-10-2 and P-10-3.

1. Perform the validation in order of an identified priority, as established between the CPUC staff and PG&E with specific interim milestones to align with the Jan 3, 2011 NTSB recommendations.
2. Identify segments where the MAOP is lower than the current pipeline Maximum Operating Pressure (MOP) and where an interim pressure reduction is warranted.
3. Identify specific components on a segment driving the reduced MAOP requirement that can be addressed through field evaluation or targeted replacement of the component

<u>Phase 3: MAOP Validation of all remaining pipelines</u>

1. Extend the work to the remainder of PG&E's gas transmission lines with the same level of rigor as applied to HCA pipeline segments without prior strength tests during Phase 2.

PG&E initially assigned a dedicated team of more than 50 employees and 50 contractors with specialties in engineering, mapping, information technology, project and document management, process controls, and auditing. This team has evolved to more than 300 professionals fully dedicated to this critical effort. The team undertook an extensive records search across the service territory to locate gas transmission records and reached out to approximately 37,000 existing and previous employees and contractors requesting relevant records that those individuals may have in their personal possession. These records are being digitally stored in a temporary electronic database known as Enterprise Compliance Tracking System (ECTS). PG&E leased and built out space in existing facilities to house project operations, including a central records repository located in Emeryville, California.

3.1.1 Project Timeline

On March 15, 2011, PG&E submitted to the CPUC its status report on the first phase of efforts to locate pressure test records for 1,805 miles of HCA pipelines. After reviewing the submission, the CPUC provided PG&E with feedback and reiterated the mandate to provide results of MAOP validation as outlined by the NTSB recommendations. The CPUC staff and PG&E further developed a plan with specific interim milestones reflecting a series of priorities for associated pipelines. This plan set forth specific milestones to complete the MAOP validation on 705 miles of HCA pipeline without prior strength test records by Aug 31, 2011.

PG&E has since completed each of the three milestones in the plan on time and filed the most recent progress report for the month ended Aug. 31, 2011 with the CPUC on Sept. 12, 2011. PG&E is working to complete the MAOP validation work on the remainder of its HCA gas transmission pipelines by the end of Jan. 2012 and is on-track to meet this milestone and then focus on non-HCA pipelines which is estimated to be completed by April 2013.
Table 1 below is a summary of the high level schedule established to achieve MAOP validation for the 6,750 miles of PG&E gas transmission pipeline:

Table 1. Project Schedule

Description of the Phases and Key Milestones/Deliverables as filed with CPUC	Completed/planned Miles (mileage numbers not cumulative)	Target Completion Date	Current Status
Begin Project		1/3/2011	Complete
Report to CPUC on pressure test records collection for HCA pipeline	1,805	3/15/2011	Complete
Key Dates of MAOP Validation for CPUC/PG&E Plan:			
Complete records collection for 152 miles of Double Submerged Arc Welded (DSAW) pipe with a 24-36” diameter and installed prior to 1962; Seamless pipe with a diameter greater than or equal to 24” and installed prior to 1974 (“Priority 1 Pipelines”) without prior strength test records		6/10/2011	Complete
Complete MAOP validation for Priority 1 Pipelines	156*	6/30/2011	Complete
Complete records collection for 295 miles of Electric Resistance Weld (ERW), Single Submerged Arc Welded (SSAW), Flash and Lap Welded and all pipe with Joint Efficiency < 1 and installed prior to 1970 (“Priority 2 Pipelines”) without prior strength test records		7/10/2011	Complete

Description of the Phases and Key Milestones/Deliverables as filed with CPUC	Completed/planned Miles (mileage numbers not cumulative)	Target Completion Date	Current Status
Complete MAOP validation for Priority 2 Pipelines	309*	7/30/2011	Complete
Complete records collection for 206 miles of 49 CFR Section 619(c) documented pipe and pipe installed prior to 7/1/1970 with records still under review and 52 miles: All pipe installed after 7/1/1970 with records still under review ("Priority 3-4 Pipelines") without prior strength test records		8/10/2011	Complete
Complete MAOP validation for Priority 3-4 Pipelines	302*	8/31/2011	Complete
Remaining milestones for HCA pipelines:			
Remaining HCA miles and additional new HCAs identified as part of the Class Location Study completed during summer of 2011	1321	1/31/2012	In Progress and On-Track
Complete MAOP validation for remainder of non-HCA pipelines	4,662	04/30/2013	
Total miles in scope	**6,750**		

* PG&E increased the miles of pipe being validated in each phase for efficiency purposes and to be able to tie starting and ending points to physical appurtenances above ground. In other words, some segments may be listed as beginning or ending at a particular pipeline mile point, but when building a PFL, it is necessary to tie starting and ending points to appurtenances, and not just a mile point on a drawing.

3.1.2 Project Methodology

The team established a process depicted in Figure 4 below and further detailed throughout this section for MAOP Validation efforts associated with Phases 2 and 3.

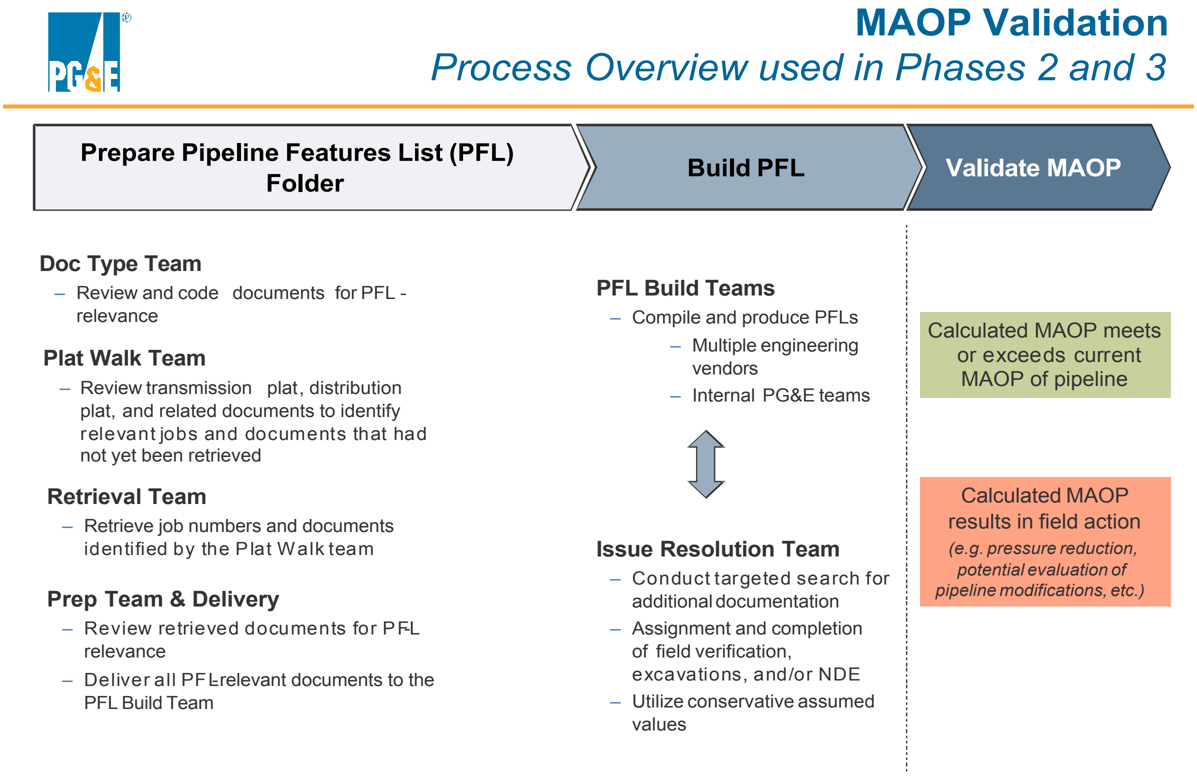


Figure 4. MAOP Validation Process Overview

Successful execution of this process was dependent upon organizing pipeline segments by the respective job file packages that include all relevant documents required for MAOP validation. This allowed a systematic approach to project execution while adhering to an extremely aggressive timeline for validating the segments associated with the identified priority. While the most efficient approach would dictate grouping sections of pipe together from Pressure Limiting Station to Pressure Limiting Station, the project team had to determine the most logical grouping of work packages focused on completing the validation for priority segments first. Figure 5 below illustrates discontinuous individual segments along a pipeline between two pressure limiting stations.

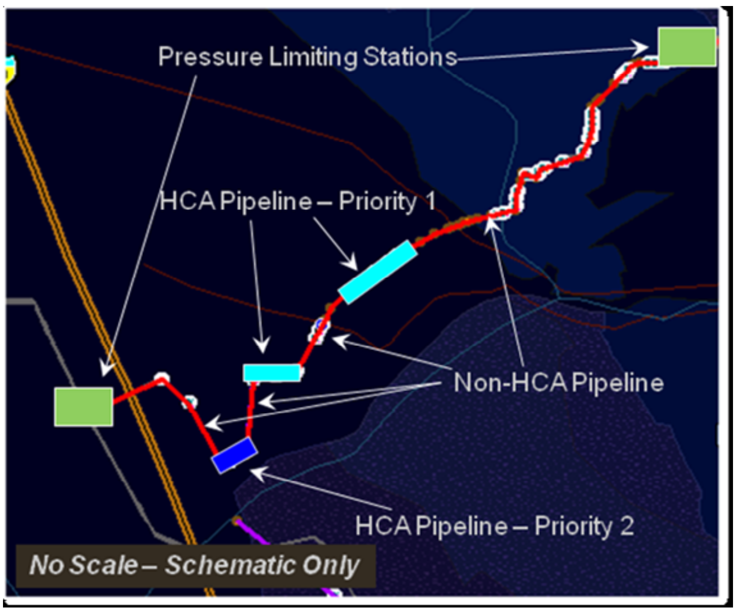


Figure 5. Schematic showing discontinuous individual segments along a pipeline

between two pressure limiting stations

PG&E's GIS and its integrity management program employ a “pipeline segment" as the basic building block. A pipeline segment typically ranges from several feet to several hundred feet in length and is comprised of pipe with consistent specifications throughout the length of the segment. The segment may also contain fittings and other appurtenances. Pipeline segments were combined into a “cluster” to make up a section of pipeline for which the PFL was to be created, as shown in Figure 6 below.

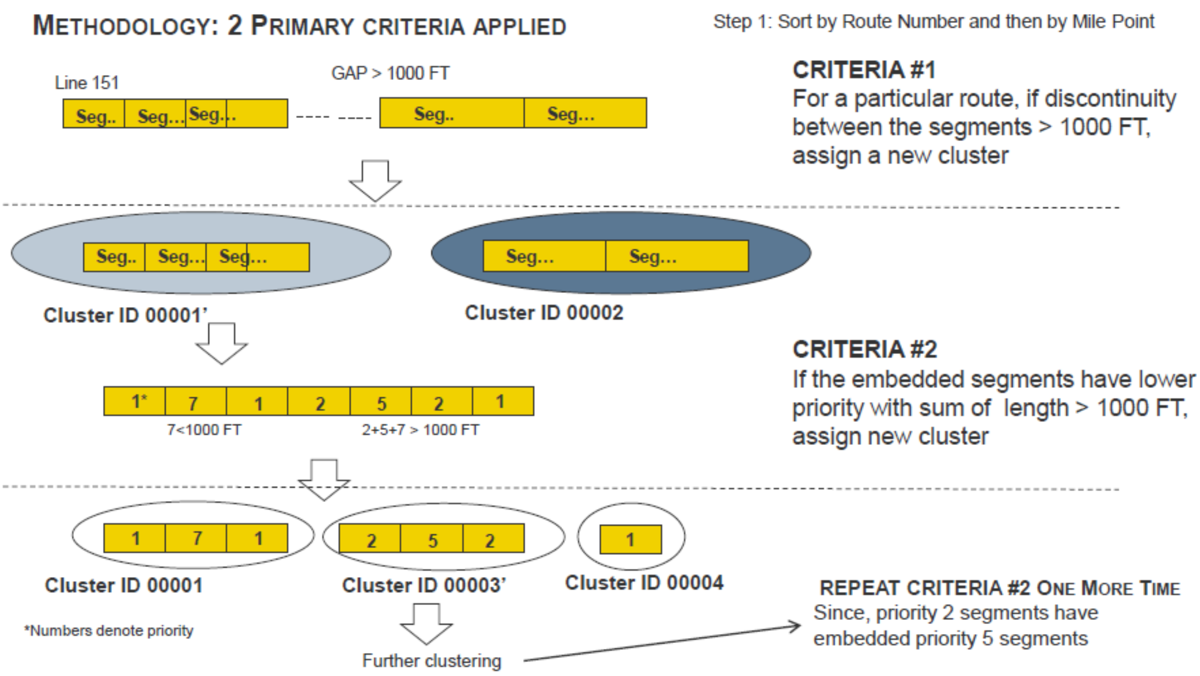


Figure 6. Defining Individual PFLs

The prioritization of building PFLs was based on agreement between PG&E and the CPUC staff. The highest priority was assigned to HCA pipelines without prior strength test records, followed by the remaining HCA pipelines and then non-HCA pipelines.

3.1.3 Project Management Office (PMO) and Independent Quality Assurance (QA)

1. A formal PMO, which comprises more than 30 PG&E and contracted resources, has been established to manage the overall project scope, schedule, cost, resources, risk and issue management, internal and CPUC reporting, and perform an independent QA and QC function. This group’s responsibilities are further defined as follows:
   a. Project leadership and direction comprise approximately 10 individuals with responsibility ranging from controlling the project strategy and logistics, production process oversight, process design and quality oversight, PFL build oversight, technical engineering advisory, and data accuracy verification work. A subset of this team also has responsibility for keeping senior leadership apprised of project status.
   b. Approximately 10 individuals are responsible for core program functions including schedule and cost management as well as metrics and data analytics throughout this effort.

A team of approximately 10 individuals are responsible for independent QA work throughout the project. QA includes continuous assessments and audits to ensure that all processes and sub processes adhere to the formally defined and documented processes. The QA work verifies that the project maintains effective change control for these processes and highlights all identified non-compliances issues. The QA work is performed based on reviewing deliverables from a statistically relevant sample obtained from various steps in the process. Data that directly impacts the MAOP validation (e.g. documents or specifications used for MAOP calculations) have a zero percent failure rate as the established criteria. This QA is performed in addition to the QC procedures that have been established for each of the sub-processes within the project defined in the following sections of this report. QC inspections are conducted to provide consistent and real-time review of the deliverables associated with these processes. QA is discussed in greater detail in section 3.4.4.

3.1.4 Systems and Technology/IT:

1. The IT group provides infrastructure for set-up and maintenance of more than 300 desktop/laptop computers and servers for records review and verification (servers and computers account for the capital costs)
2. IT also supports a variety of systems including ECTS, coordinates with vendors to support the development of the enhanced GIS platform , and maintains a variety of electronic file exchange protocols such as File Transfer Protocol (FTP) sites and conducts application setup, maintenance, and support as required

3.2 PFL Folder Preparation

The ultimate goal of the Pipeline Features List (PFL) Folder Preparation process is to identify, retrieve, scan, and organize all relevant documents relating to specific pipeline segments required for the development of PFLs. Examples of relevant documents includes As-Built Construction Drawings, Plan and Profile Drawings, Bills of Material, Gas Material Requisitions, Specifications, Inspection/Test Forms, and Operating Pressure Charts for pipeline segments and respective components (e.g. valves, sleeves, elbows, fittings, etc.). This will allow the development of traceable, verifiable and complete PFLs for all pipeline components.

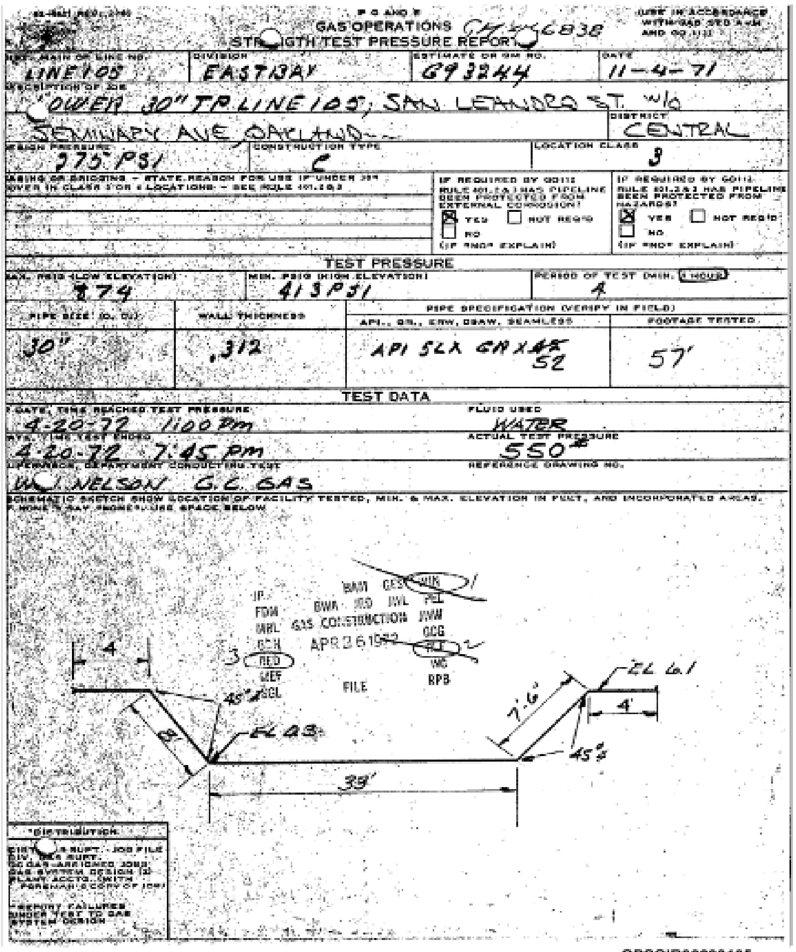
3.2.1 Phase 1 – Strength Test Records Verification (January – March 2011)

The objective of Phase 1 was to collect and review documentation for 1,805 miles of HCA pipelines to identify the sections with traceable, verifiable and complete STPRs.
PG&E established the definition of traceable, verifiable and complete STPRs as follows:

- Traceable: STPR needs to correlate to a specific pipeline or section (for this phase, the information on the STPR including pipe specifications and footage needs to be in agreement with the Face Sheet, As-Built Drawings or Bill of Material Records).
- Verifiable: Pressure test record (STPR) exists and has been collected and reviewed
- Complete: For an STPR to be “complete,” it must contain the following four elements: 1) the name of the operator, 2) test pressure, 3) test duration, and 4) test medium. There are three additional recordkeeping elements in 49 CFR §192.517(a): “(5) Pressure recording charts, or other record of pressure readings; (6) Elevation variations, whenever significant for the particular test; and (7) Leaks and failures noted and their disposition.” With respect to “(5) Pressure recording charts, or other record of pressure readings,” the STPR contains a field for contemporaneous entry of the pressure reached, which is “[an]other record of pressure readings.” Wherever available, PG&E confirmed that the pressure reached on the pressure chart correlated with the pressure entered on the STPR. Elevation variations, and leaks and failures and their disposition, would not logically exist for every pressure test, but only those where elevation variations were

significant for the test or where leaks were found. PG&E documented these elements when applicable and available.

See Figure 7 below for an example of a complete STPR.


P G AND E
GAS OPERATIONS
STRENGTH TEST PRESSURE REPORT
(USE IN ACCORDANCE WITH GAS STD A-34 AND GO 112)

MAIN OR LINE NO.	DIVISION	ESTIMATE OR GM NO.	DATE
LINE 105	EAST BAY	693244	11-4-71

DESCRIPTION OF JOB: LOWER 30" TP LINE 105; SAN LEANDRO ST. W/O SEMINARY AVE, OAKLAND
DISTRICT: CENTRAL

DESIGN PRESSURE	CONSTRUCTION TYPE	LOCATION CLASS
275 PSI	C	3

IF REQUIRED BY GO112 RULE 401.2A.1 HAS PIPELINE BEEN PROTECTED FROM EXTERNAL CORROSION? [X] YES [ ] NOT REQ'D [ ] NO (IF "NO" EXPLAIN)
IF REQUIRED BY GO112 RULE 401.2A.2 HAS PIPELINE BEEN PROTECTED FROM HAZARDS? [X] YES [ ] NOT REQ'D [ ] NO (IF "NO" EXPLAIN)

TEST PRESSURE

MAX. PSIG (LOW ELEVATION)	MIN. PSIG (HIGH ELEVATION)	PERIOD OF TEST (MIN. 1 HOUR)
774	413 PSI	4

PIPE SIZE (O.D.)	WALL THICKNESS	PIPE SPECIFICATION (VERIFY IN FIELD) API., GR., ERW, DSAW, SEAMLESS	FOOTAGE TESTED
30"	.312	API 5LX GR X45 52	57'

TEST DATA

DATE, TIME REACHED TEST PRESSURE	FLUID USED
4-20-72 1100 PM	WATER

DATE, TIME TEST ENDED	ACTUAL TEST PRESSURE
4-20-72 7:45 PM	550#

PERSONNEL, DEPARTMENT CONDUCTING TEST	REFERENCE DRAWING NO.
W. J. NELSON G.C. GAS	

SCHEMATIC SKETCH SHOW LOCATION OF FACILITY TESTED, MIN. & MAX. ELEVATION IN FEET, AND INCORPORATED AREAS.

DISTRIBUTION:
DIST. SUPT. - JOB FILE
DIV. GAS SUPT.
GC GAS - ASSIGNED JOBS
GAS SYSTEM DESIGN
PLANT ACCTG. (WITH FOREMAN'S COPY OF JOB)
REPORT FAILURES UNDER TEST TO GAS SYSTEM DESIGN

GPSOIR00200165

Figure 7. Sample Complete STPR

Implementation of this phase of the project included retrieving job files consisting of As-Built Construction Drawings, Purchase Orders, STPRs and other documents from more than 60 offices throughout PG&E's service territory and correlating the documents to specific pipeline segments. Due to the compressed schedule, PG&E quickly developed and trained a new organization consisting of a team of more than one-hundred employees and contractors within a month to meet the objectives of this phase of the project. In order to organize the documentation, provide a centralized digital library, and manage workflow, an electronic database and tracking system was necessary. It was recommended to enhance the pre-existing compliance system, Enterprise Compliance Tracking System (ECTS). This effort required basic functionality changes with respect to process flow, data retention, and enhanced process capabilities. ECTS provided two immediate benefits: audit capabilities with the ability to track changes and the ability to readily update the code as necessary to meet the project requirements.

For the appropriation of Phase 1 tasks to respective groups, see Figure 8 below.

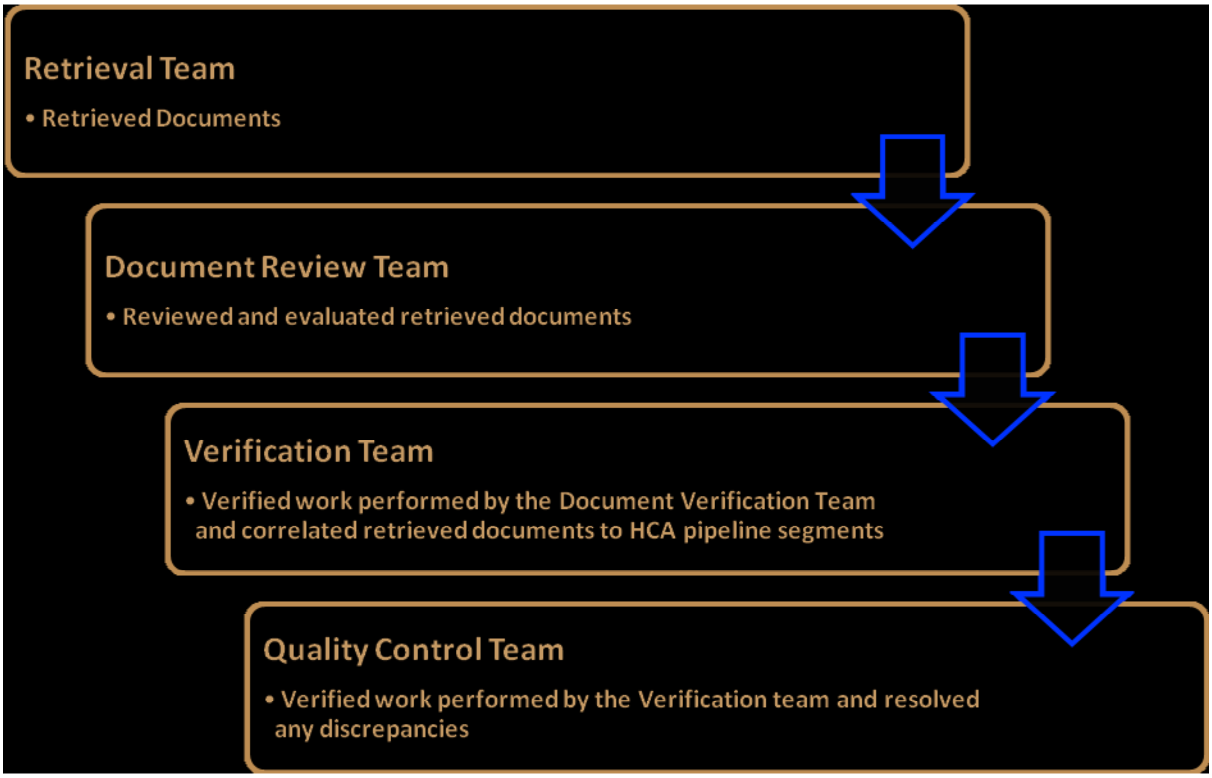


Figure 8. Records Collection Process - Phase 1

3.2.1.1 Retrieval Team

In order to collect the necessary documentation for Phase 1, PG&E extracted all jobs numbers related to the 1,805 HCA miles from the current version of the GIS database on transmission pipeline segments including pipeline route, mile point range, unique segment number, and job number and then associating the segments with one of the three relevant phases of the Records Verification and MAOP Validation Project. All other pipe asset data including specifications and strength test data were not leveraged for any purpose associated with the project. Efforts focused on retrieving physical records corresponding to those job numbers. Any job folders in the field offices that corresponded to the required job numbers were boxed and transported to a centralized storage facility in Emeryville, California. The job folders were inventoried, bar coded, scanned, and subsequently uploaded into ECTS.

The five primary document types targeted for upload and review based on their relevance to the Phase 1 effort were:

1. Face sheets
2. Construction drawings
3. Strength Test Pressure Reports (STPR)
4. Strength Test Pressure Report Charts (STPR Chart)
5. MAOP Document

While the retrieval effort focused on retrieving entire job folders in preparation for the completion of Phases 2 and 3, these five document types provided the necessary information to validate the location of the pipeline section and the testing status of those sections, and were therefore prioritized for scanning and upload.

3.2.1.2 Document Review Team

The function of the Document Review Team was to perform the initial review of scanned and coded documents that had been entered into the ECTS database. In addition, the team analyzed the quality of the document (i.e. the relevance and completeness of the document) and identified and coded the job numbers related to the document. They also performed an initial comparison of the footage shown on Face Sheets with the footage that was tested according to the STPRs for the identified section of pipe.

3.2.1.3 Verification Team

The Verification Team verified the work completed by the Document Review Team to determine that the best representation and most complete documents were identified and the assessment was performed correctly. They then reviewed and balanced all footage between STPRs, face sheets, and GIS segments. The verification required is that the tested footage on the STPRs must match or exceed the total footage on the face sheet[2] for the respective section of pipe.

3.2.1.4 Quality Control (QC) Team

As with all teams for Phase 1, the QC Team's first task was to verify the work of the previous team, the Verification Team. The QC Team then independently verified the correlation between STPRs, Face Sheets, and GIS segments. Since the QC Team consisted of the most experienced pipeline engineers on the project, it was tasked with resolving discrepancies and reviewing all updates and other complicated pipeline segments.

3.2.1.5 Summary and Discussion

PG&E completed and submitted the results of the Phase 1 efforts to the CPUC on March 15, 2011. The deliverable was a report identifying the portion of the 1,805 miles for which complete pressure testing documentation could be verified. During Phase 1, the PFL Folder Preparation team successfully gathered, scanned, and uploaded approximately 1.2 million documents and reviewed each document for relevance.

3.2.2 Phases 2 and 3 – MAOP Validation of all pipeline segments (April 2011 and beyond)

In Phases 2 and 3, PG&E is constructing PFLs for all PG&E transmission pipeline using the documents collected in Phase 1 as well as additional documents collected through a targeted approach in Phases 2 and 3. The data collected in the PFLs is used to validate the MAOP of each pipeline component and where the component MAOP is lower than the current pipeline MOP, an interim pressure reduction is taken or additional field action including pressure test or replacement is performed.

For the PFL Folder Prep process, the objective of Phases 2 (complete) and 3 (currently underway) was to identify and deliver relevant documents needed to complete the PFL build of a group of pipeline segments to the PFL Build team. While it was understood that some additional retrieval would be required, PG&E initially operated under the assumption that the retrieval effort in Phase 1 identified and processed the majority of the necessary job folders required to complete Phase 2. It was quickly discovered that the job numbers retrieved in Phase 1 (based solely on the GIS data) were only a fraction of the job numbers required for Phase 2 since additional necessary job numbers were listed on Transmission and Distribution Plat maps and only a fraction of the documents retrieved in preparation for Phase 2 were processed and uploaded to ECTS prior to implementing Phase 2. As a result, additional resources were added to the retrieval teams to expedite retrieval efforts. The PFL Prep process evolved into the current process shown in Figure 9 below.

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[2] Some exceptions applied on a case by case basis.

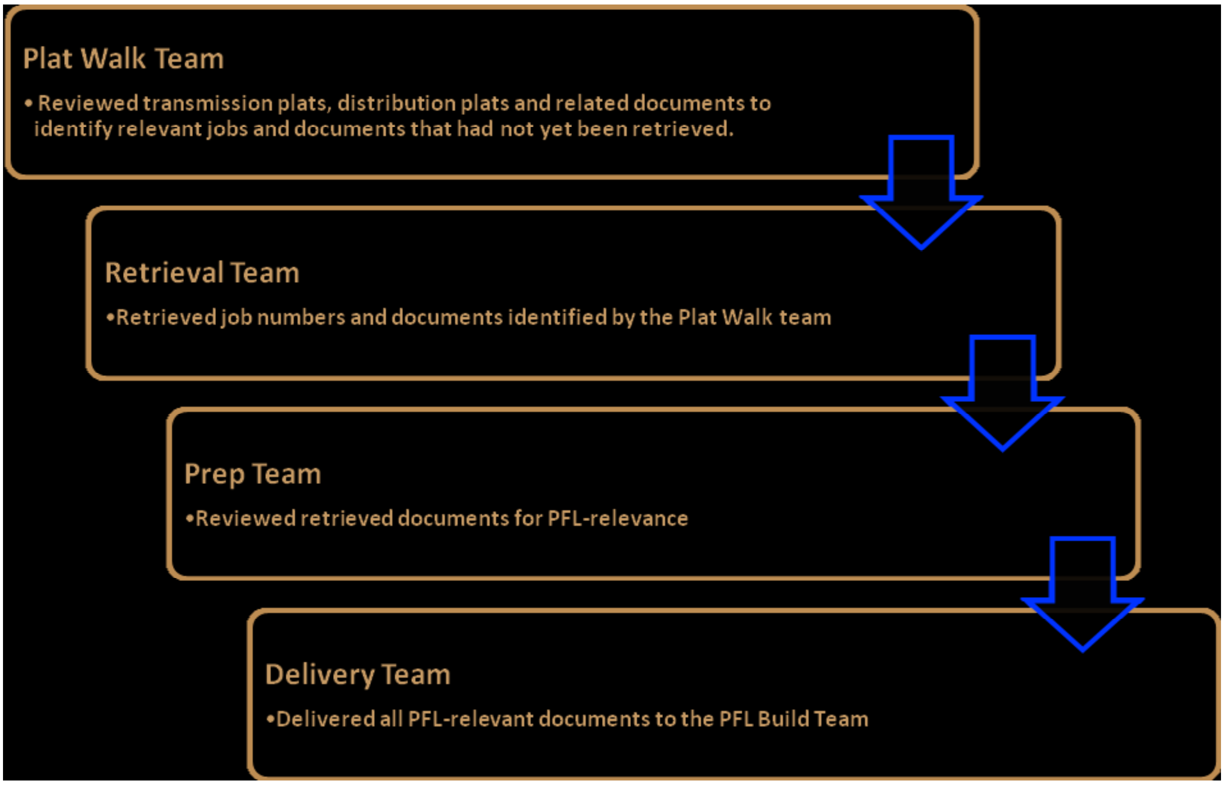

Figure 9. MAOP Data Validation PFL Folder Preparation – Phases 2 and 3

Each assignment went through the PFL Prep process following four sequential steps: (1) Identifying job numbers and documents that could be necessary for the PFL Build process, (2) Retrieving the job numbers for which sufficient documentation did not already exist in ECTS, (3) Reviewing documents currently in ECTS and additional documents that were retrieved, and (4) Packaging the relevant documents and delivering those to the PFL Build team.

3.2.2.1 Plat Walk Team

As the Phase 2 process developed and feedback was received from the PFL Build team, it was noted that the initial retrieval effort performed in Phase 1 - based on job numbers corresponding to pipeline segments on the data extraction from PG&E's GIS - was incomplete. While the extracted list of job numbers was beneficial, it was not indicative of all the job numbers required for PFL Build.

Originally, the purpose of the Plat Walk team was to identify regulators and customer taps and request required documents that had not yet been retrieved or searched for in the field. This included identification of all Distribution Plat maps (see Figure 10 below for an example of a distribution plat map), H-forms, Operating Maps, and Operating Diagrams within PG&E's GIS. The Plat Walk Team digitally reviewed ("walked") Distribution Plat maps and used GIS to determine which specific job numbers and documents needed to be requested from the field retrieval team. Following retrieval and upload of images, all relevant documents were digitally associated to corresponding pipeline segments within ECTS. To ensure quality, the Plat Walk process was performed by separate parties in two passes: an initial review and a 100% quality check.

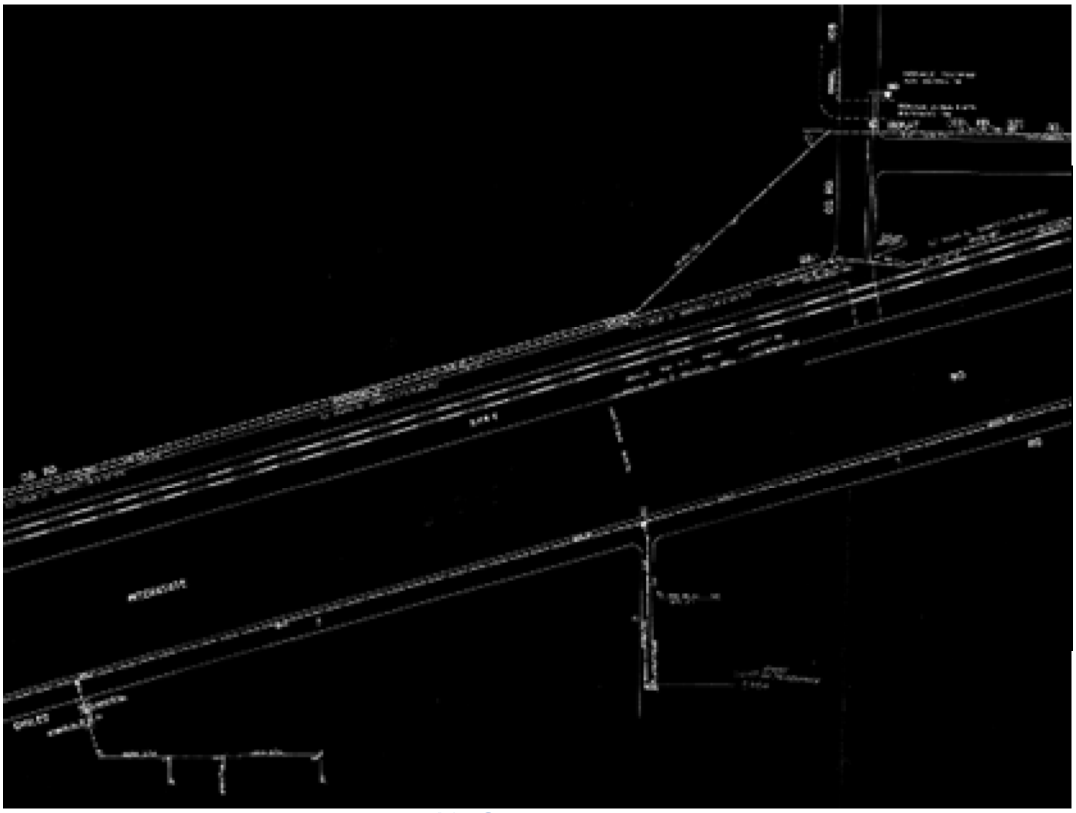

Figure 10. Sample Distribution Plat map

Even though Transmission Plat maps have not been updated since approximately 1984, based on feedback from the downstream PFL Build team, it was determined that in addition to jobs identified on the distribution plats, there was significant value in retrieving historic job numbers on the transmission plat maps (see Figure 11 below for an example of a transmission plat map) to complete the PFL. Because of the scope of additional review, a new Transmission Plat team was created. Their objective was to review Transmission Plat maps, GIS, and related documents already digitized in PG&E's Engineering Document Management System (EDMS). They "walked" the segments of their given assignment to determine job numbers that needed to be considered while building the PFL, and initiated requests for the field retrieval teams for any job numbers that did not have sufficient documentation in ECTS. All field requests were centralized within the database to reduce duplicating requests and to perform the search in a consistent manner. Following retrieval and upload of images, all relevant documents were digitally associated to corresponding pipeline segments within ECTS. To ensure quality, the Transmission Plat duplicated the two-pass system employed in the Plat Walk process.

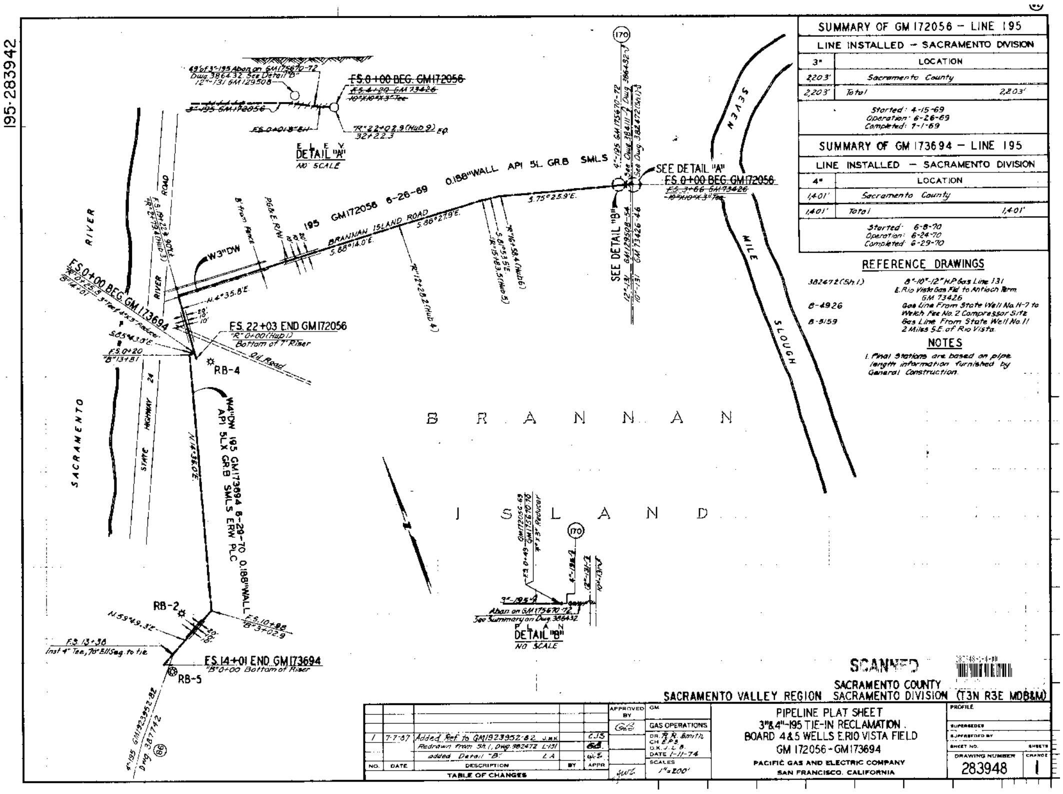

Figure 11. Sample Transmission Plat map

The Transmission Plat team was consolidated with the Plat Walk team to gain efficiencies in conducting this work.

3.2.2.2 Document Retrieval Team

<u>Phase 2 (April 2011-August 2011)</u>
The Document Retrieval Team for Phase 2 initially focused on retrieving documents from the field offices. This team fulfilled the requests generated by the Plat Walk team. Since the approach to completing pipeline segments was based primarily on priority and was only partially based on geographical location, it proved to be very inefficient from both a time and cost perspective to retrieve the requested documents. When the Transmission Walk process was implemented and the Plat Walk process was modified to require significantly more document retrieval, the field retrieval team quickly became a bottleneck in providing required documentation to the PFL Build team in a timely manner.

The retrieval team was modified to take a more efficient approach. Two major changes made to the retrieval process were (1) Modifying the prioritization process to consider both the segment priority and field office location and (2) Retrieving documents from the PG&E Records Collection Centre in Emeryville, California before searching for them in outlying field offices. PG&E's service territory has been shown earlier in the document and the field offices are spread (more than 60 locations) throughout this territory. In addition to the massive retrieval effort of job folders, the entire population of documents from various field office locations were sent to Emeryville to be scanned, reviewed, and uploaded to the electronic database..

The first step in this modified retrieval process was to review a database containing a summary of job numbers located in Emeryville. If a job number was identified, these documents were pulled from the Emeryville warehouse shelves, the PFL documents were digitized, and retrieved. If it was determined that the documents retrieved were representative of the documents located in the field, then that job number was considered retrieved, and it was deemed unnecessary to send any additional resources out to PG&E field offices to retrieve what would likely be duplicate images. To ensure all relevant documents were included for PFL build, a process was put into place to support PFL Build by conducting retrieval of targeted documents or job numbers that were not included in the initial build package.

After the Emeryville Retrieval process was complete, the remaining outstanding documents and job numbers were retrieved via the Field Retrieval process, which included:

1. Retrieving requested documents at the field offices
2. Scanning PFL-relevant retrieved documents
3. Uploading the retrieved documents to ECTS
4. Verifying all retrieved documents were uploaded properly

Phase 3 (August 2011 and beyond)

As implemented in Phase 2, Phase 3 retrieval consists of Emeryville Retrieval and Field Retrieval.. In addition to submitting and uploading all relevant documents that are already housed at Emeryville and In an effort to digitize all documents, create a centralized storage facility, and develop a chain of custody history for all job folders, job folders retrieved from the field are (1) Bar-coded and boxed at the field office (2) Sent to Emeryville for scanning and storage and (3) Uploaded to the database. To help ensure that job folders are not misplaced or lost, a barcode tracking system is used to track the physical location of the job folder en route to and in Emeryville as well as the status of the digital file through upload to ECTS. Field office personnel can electronically access all of the documents removed from their offices using ECTS.

Reviewing Retrieved Documents

Before uploading the retrieved documents to ECTS, the documents are reviewed and coded for PFL-relevance. To ensure quality, the coding was performed in two passes: an initial review and a 100% quality check each performed by separate parties. The categories of relevant document types expanded from the 5 document types targeted in Phase 1 to 43 document types in Phases 2 and 3 (see Table 2 below). Initially, PG&E created categories for all documents in the system, but quickly learned that in order to meet the Phase 2 deadlines, the scope needed to be refined in order to focus on reviewing and coding only PFL-relevant documents. The scope of the document types was focused on only PFL-relevant documents. All remaining documents outside of this population were grouped into a “Non-PFL” category. Refer to the glossary for a description of each document type.

Table 2: Progression of review of document types in PFL Folder prep process through the Phases

	Progression of Review of Document Types in PFL Folder Prep Process Throughout the MAOP Validation Project		
	Document Types	**Phase 1**	**Phases 2 and 3**
Job Estimates	Detail Sheet		X
	Face Sheet	X	X
Drawings	Construction Drawing	X	X
	Detail Drawing		X
	Distribution Plat Map		X
	Index Drawing		X

	Other Drawing		X
	Plan & Profile Drawing	X	X
	Transmission Plat Map		X
	Vicinity Drawing		X
Reports & Forms	A-Forms & Leak Test/Report		X
	Gas Service Record (GSR)		X
	H-Form		X
	Hydrostatic Test Plan		X
	Inspection/Test Form		X
	MAOP Document	X	X
	Operating Pressure Chart		X
	Operating Pressure Log		X
	Regulator Data Sheet		X
	Strength Test Pressure Report (STPR)	X	X
	Strength Test Pressure Report Chart	X	X
	Strength Test Pressure Report Log	X	X
	Strength Test Pressure Report Sketch	X	X
	Uprate Procedure Document		X
	Valve Maintenance Record (VMR)		X
	Weld Map		X
	X-Ray Document		X
Materials	Bill of Material		X
	Engineering Materials Memo (EMM)		X
	Gas Invoice		X
	Gas Material Requisition		X
	Gas Transport Tag		X
	Mill Test		X
	Specifications		X
Accounting	Gas Journal Voucher		X
Miscellaneous	Miscellaneous Document		
	Non-PFL Document		
	Soils/Trenching Information		

3.2.2.3 Prep Team

The primary responsibility of the Prep Team is to review documents that have been scanned, uploaded and indexed in ECTS and associate relevant documents from that population to the respective pipeline segment while filtering out any duplicates. A digital library of the relevant documents with the associated pipeline segments is then created within ECTS so that it can be used by the Delivery team.

3.2.2.4 Delivery Team

The Delivery team verifies that all job numbers required for a particular assignment have been reviewed by the Prep team. They then extract all relevant job folder documents for job numbers associated to an assignment from ECTS, perform a quality check to ensure that all documents were extracted and organized properly and deliver them to the PFL Build team for review and use.

3.2.2.5 Summary and Discussion

All of Phase 2 has been completed in the PFL Prep process and work is currently underway for Phase 3. Over the past 15 months, PG&E has undergone a monumental, foundational shift with respect to gas transmission data and records management. The refinement of that process continues, but along the way, the PFL Prep team has identified and initiated improvements in several key areas that have greatly improved the overall efficiency and quality of the process.

3.3 PFL Build

The NTSB recommendation and the requirement from the CPUC that PG&E use "traceable, verifiable, and complete records to validate the MAOP", leads to using original source documents such as invoices, purchase orders, as-built construction drawings, and pipe manufacturing mill test reports to perform this validation. By analyzing the original source documents for every pressure-containing pipeline component, a robust and detailed process is employed to complete this work.

Due to the level of detail being captured and the extensive scope of the MAOP Validation project, several engineering vendors were leveraged to assist in the completion of the pipeline feature lists. Prior to on-boarding, each vendor was subjected to a qualification process which included a one week trial PFL build that was evaluated in detail by the onsite PG&E quality control team. Provided the trial PFL met PG&E requirements, the vendor was then asked to participate in a structured training course where PFL basics, as well as advanced training topics were covered ensuring a high quality and consistent deliverable from each of the respective vendors.

3.3.1 Creating the PFL Spreadsheet

For each section of a transmission pipeline, the original source documents (database image files) are reviewed in detail by the PFL Prep team as discussed above. A subset of documents is produced - those that are most relevant for determining pressure limits of pipeline components and providing full material traceability. Examples include as-built drawings and material purchase orders containing material specifications such as pipe wall thickness and Specified Minimum Yield Strength (SMYS). This document subset is then assessed by the PFL build team engineers (currently more than 200) to confirm that the subset of documents is sufficiently complete, or whether additional research is needed to improve the quality and completeness required to validate pressure limits. If more information is required, the PFL build team performs additional research in PG&E's document and data repositories to obtain the required information.

The PFL itself consists of a catalogue in a tabular format in which each row creates a record of data for a respective pipeline component. While efforts are focused on pressure containing features, non-pressure containing components are also captured including casings and pipe supports. Pipeline components, (rows) are organized in a geographic consecutive order as identified on the respective installation drawings. For example, the order of components can include: pipe, valve, pipe, tap, pipe, etc. For each component, specifications are captured such as diameter, wall thickness (WT), SMYS, ANSI rating, coating information, etc. This data is generated by reviewing the source documents. Pertinent data is extracted during a detailed review of these documents, and the data is then catalogued in a tabular format, identified as a PFL.

The following images of a typical PFL are provided to give perspective of the data being collected. This first portion of the PFL (shown in Figure 12 below) contains basic identification, size and location information. There are different types of components including pipe, bend, tap, tee, valve, meter, cap, pressure control fitting (PCF), reducer, etc. The "Type" column identifies the specific type of a given feature. An example follows: if a tee is selected, option types include: straight tee, reducing tee, cross tee, etc.

22 Version	PFL Spreadsheet for line	7218-01						Mainline	148
Beg Station	End Station	GIS Pipe Segment ID	Class Loc.	Job Number	Install Date	Feature Number	Feature	Type	Length
0+00.0	0+00.5	101	3	166428	2/15/1967	1.0	Pipe	In station	0.5
0+00.5	0+00.8	101	3	166428	2/15/1967	2.0	Flange	Weld Neck	0.3
0+00.8	0+02.2	101	3	166428	2/15/1967	3.0	Valve	Plug	1.4
0+02.2	0+02.5	101	3	166428	2/15/1967	4.0	Flange	Weld Neck	0.3
0+02.5	0+03.0	101	3	166428	2/15/1967	5.0	Pipe	In station	0.5
0+03.0	0+05.4	101	3	166428	2/15/1967	6.0	Tee	Reducing Tee	2.4
0+05.4	0+07.2	101	3	166428	2/15/1967	7.0	Tee	Reducing Tee	1.8
0+07.2	0+07.7	101	3	166428	2/15/1967	8.0	Pipe	In station	0.5
0+07.7	0+07.7	101	3	166428	2/15/1967	9.0	Tap	Connection	0.0
0+07.7	0+08.2	101	3	166428	2/15/1967	10.0	Pipe	In station	0.5

Figure 12. PFL Spreadsheet Illustration

The second set of columns supplements the identification data with MAOP critical specifications for each feature, shown below. Data in these columns include outer diameter (OD), wall thickness (WT), seam type, SMYS, and ANSI rating. As shown below in Figure 13 by the gray cells, not all information is applicable to all types of features.

MAOP Specifications							
O.D. 1	W.T. 1	O.D. 2	W.T. 2	Seam Type	Specification / Rating	SMYS	ANSI- WOG Rating
8.625	0.216			Seamless	API 5L-B	35,000	
8.625					Unknown	unknown	ANSI 300 #
8.625				N/A - Valve/Filter/Other			ANSI 300 #
8.625					Unknown	unknown	ANSI 300 #
8.625	0.216			Seamless	API 5L-B	35,000	
12.750	0.375	8.625	0.322	Unknown > 4 inch	Grade B	unknown	Unknown
12.750	0.375	6.625	0.280	Unknown > 4 inch	Grade B	unknown	Unknown
12.750	0.312			Seamless	API 5L-B	35,000	
0.500					Unknown	unknown	Unknown
12.750	0.312			Seamless	API 5L-B	35,000	

Figure 13. Critical specifications for each feature in the PFL

As the PFL builder progresses to the right of the PFL, non MAOP critical data can be input which provides a more complete data set and traceability information. As shown below in Figure 14, these columns include purchasing information and material codes.

Coating			Purchase and Install			
Coating Type	Coating Desc.	Coating Install Date	MFG	Material Code	Purchase Doc #	Purchase Date of Feature
Paint	Not specified	2/15/1967		01-9990	1482188	9/13/1966
Paint	Not specified	2/15/1967		02-5232	1680809	9/21/1966
Paint	Not specified	2/15/1967	Nordstrom	03-4221		
Paint	Not specified	2/15/1967		02-5232	1680809	9/21/1966
Paint	Not specified	2/15/1967		01-9990	1482188	9/13/1966
Paint	Not specified	2/15/1967		02-2446	1482185	9/13/1966
Paint	Not specified	2/15/1967		02-2431	1680839	10/31/1966

Figure 14. Non-MAOP critical data in the PFL

Strength test information is also captured in the PFL on the component level. This allows for a detailed analysis where each component is determined to have been tested or not tested based on as-built drawings, STPR pipe specifications, and STPR sketches. Minimum indicated test pressure, adjusted test pressure (for elevation changes), test duration, and medium are all captured. Complete STPR packages are recorded including the test report, charts, sketches and dead weight logs. This information can be critical in the determination of MAOP for each component.

To maintain full and complete traceability of pipe specifications to original source documentation, the reference image names as identified in ECTS are listed for each component. The listed images (source documents) directly support each specification included in the PFL. In this manner, every value in the PFL is supported by the referenced images. Each image (document) is ranked by its quality. A “Q1” document is the highest quality, representing full traceability to the installation job and is witness to installation. An example of a Q1 document would be a mill test report (often containing chemical analyses and mechanical property data) with a purchase order number, which links the materials installed on a job to a specific heat of steel. Lower Q ratings (Q6, for example), may represent early intent, but are not witness to installation. These may include material requisitions or proposed construction drawings. Typically the data from low Q rated documents is not applied in the PFL. An example of the reference image columns of the PFL with Q ratings is shown below in Figure 15. This step ensures that the data available to verify the information that was used is clearly documented to establish the traceability of the information that is used on the PFL. The quality ranking of documents ensures the correct data is captured. For example, a proposed drawing (Q6) may indicate 0.3125” wall thickness pipe was to be used but the as-built drawing (Q3) may show 0.375” was actually installed. This rating system provides a systematic methodology for capturing the correct data. Additionally, the quality ranking system provides a level of certainty as to what was installed. This information is one of the key drivers in identifying the need for excavations to validate the MAOP so that data with a high level of certainty can be used for this purpose.

Reference Document Images [ECTS]						Reference Maps	
Image Name 1	Image 1 Quality	Image Name 2	Image 2 Quality	Image Name 4	Image 4 Quality	Operating Map or Diagram	Distribution Wall Map and Plat Sheet
MAOP00068592.TIF	Q3	MAOP00298139.tif	Q2	MAOP00068591.TIF	Q3	3851623	3235-E01
MAOP00068592.TIF	Q3	MAOP00298132.jpg	Q2	MAOP00068591.TIF	Q3	3851623	3235-E01
MAOP00068592.TIF	Q3			MAOP00068591.TIF	Q3	3851623	3235-E01
MAOP00068592.TIF	Q3	MAOP00298132.jpg	Q2	MAOP00068591.TIF	Q3	3851623	3235-E01
MAOP00068592.TIF	Q3	MAOP00298139.tif	Q2	MAOP00068591.TIF	Q3	3851623	3235-E01
MAOP00068592.TIF	Q3	MAOP00298134.tif	Q2	MAOP00068591.TIF	Q3	3851623	3235-E01
MAOP00068592.TIF	Q3	MAOP00298133.tif	Q2	MAOP00068591.TIF	Q3	3851623	3235-E01

Figure 15. Example of PFL reference image columns with Q ratings

Following careful review of the original source documents, selected values may remain unknown if adequate documentation cannot be located, or if discrepancies exist. These fields are marked as “unknown” and the issues are logged for review by the IR group, which reviews all PFLs downstream of the Build and QC processes. It should be noted that the PFL build team makes no assumptions regarding unclear or missing data, with few exceptions authorized by subject matter experts where the assumptions cause no adverse integrity issues with the data.

Prior to submission of the PFL to PG&E by the respective engineering vendor, each PFL is subjected to a full 100% check by the build vendors. This is performed independently of the PFL build process, ensuring quality data by an impartial second pass. Additionally, a letter of transmittal accompanies each PFL and is signed by a registered and licensed professional engineer verifying the PFL has been reviewed and approved by the respective engineer.

In summary, the PFL build process transfers specifications from drawings, purchase orders, invoices, transport tags, and the like to develop the PFL where full traceability can be maintained for each pipeline component by referencing the necessary documents.

3.3.2 PFL Quality Control (QC)

Following the initial PFL build process and 100% check by the build vendor, all PFLs are subject to a complete review by PG&E’s Quality Control (QC) group, typically a team of between 35 and 40 engineers. The QC team, made up of a two-pass system, reviews all of the original source documents associated with each PFL to confirm all PFL data is consistent and accurate. The QC team also searches for possible missed documentation as needed to improve the quality of the data in the PFL, specifically for those components with specifications identified as “unknown.” In addition to the corrected PFL, the QC team also produces a list of suggestions to the Build team, including trending of errors that improve build quality when identified and addressed. Two metrics are used to evaluate build quality: completeness and accuracy. Completeness analyzes possible missed features, while accuracy compares specifications transferred incorrectly from the respective source documents or the use of a lower quality document (Q2) instead of a higher quality document (Q1). These metrics are generated for all PFLs and provide an objective measure of quality. With the aforementioned feedback loop and metrics, the overall initial PFL Build quality by the engineering vendors has increased dramatically over time and reduced a significant amount of rework.

3.4 Issues Resolution

It is not uncommon to find that older pipeline records used in the development of PFLs described in preceding sections, lack sufficient detail needed to perform MAOP validation.

3.4.1 Tools used to collect additional data

There are three primary tools that are leveraged in this instance.

1. Additional records research, as deemed appropriate.
2. Application of conservative assumptions regarding pipeline component specifications.
3. Field investigation of pipeline components

3.4.1.1 Additional Records Searches

If during its initial review, the IR Team identifies a need for additional information, it may request that the PFL build team conduct further records research and attempt to resolve outstanding issues such as missing or conflicting information regarding component specifications. Because the initial development of the data in a PFL has been the result of a comprehensive and detailed search and review of all construction and operating records, it is rare that additional records research results in significant, if any, changes at all.

3.4.1.2 Application of conservative assumptions for pipeline component specifications

Industry and/or PG&E historical standards are used as references to identify conservative assumptions for unknown component specifications. Firstly, PG&E has adopted the conservative assumption that if the purchase date for a component is unknown and cannot be approximated, it is possible that the component could have been purchased much earlier than the installation date. Hence, the range of possible specification assumptions includes the timing adjustment between the installation and purchased dates with the most conservative value being identified for the unknown specification in the PFL throughout this time period.

As an example of the application of this process, the process diagram in Figure 16 below illustrates the basic logic employed at the start of any effort to produce an assumption for an unknown specification value associated with a “pipe” component with an unknown seam type and joint efficiency factor.

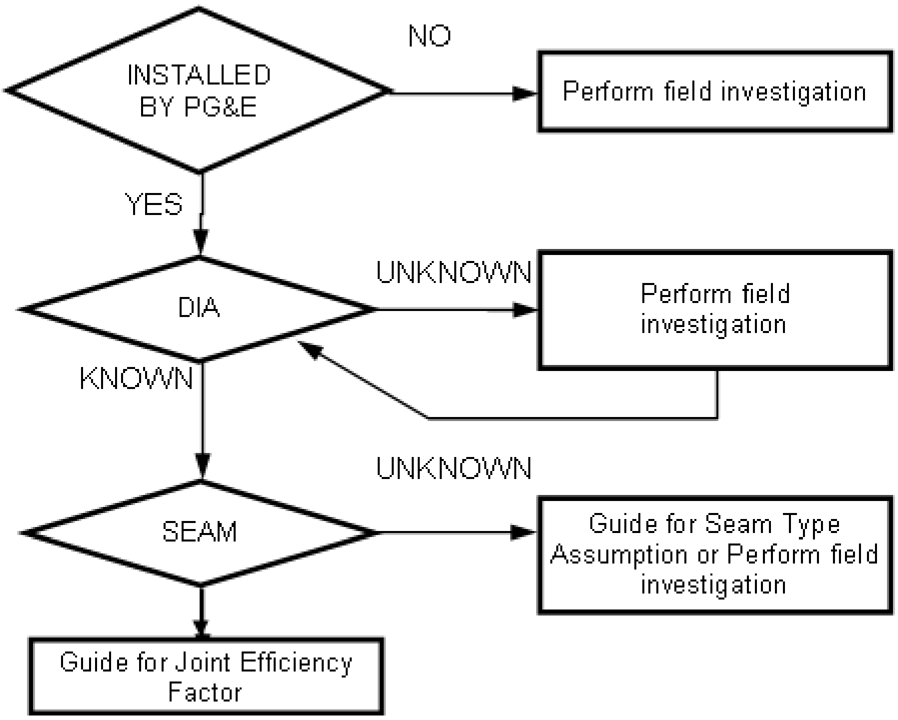

Figure 16. Logic to produce an assumption for an unknown specification value

<u>Pipeline System Acquired from Other Operators</u>

In a few instances, PG&E's transmission system contains pipe and components installed by other operators. Documentation associated with the purchase of these systems by PG&E in the 1950s and earlier is usually inadequate to identify component specification. Since the components were not purchased for installation by PG&E, historical PG&E engineering standards and component purchasing practices are not relevant. Conservative assumptions aligned with the DOT Code of Federal Regulations, 49 CFR 192 can be applied in these instances. For example, 49 CFR part 192 allows the use of 24,000 PSI SMYS as an assumption in instances where the pipe yield strength is unknown. In some instances, field investigations will be required to establish specification values, as shown in the diagram for these pipeline systems.

Pipeline System Installed by PG&E

A primary specification on which assumptions are based is the diameter of the pipe or related component. PG&E rarely, if ever, encounters situations during the PFL build process where the diameter is unknown. However, in situations where the diameter is unknown or uncertain, field verification must be conducted to establish this value.

After the diameter is identified and in situations where the seam type is unknown, historical PG&E standards and purchasing practices combined with industry manufacturing standards and 49 CFR 192 are employed to derive the appropriate conservative assumption of seam type and associated joint efficiency factor. Table 3 below is an excerpt from PG&E's standard illustrates the information used to determine a conservative assumption for an unknown seam type for four-inch diameter pipe on PG&E's system.

Table 3. Information used to determine a conservative assumption for an unknown seam type

4" diameter	Unknown Date	≤ 1/30/55	≥ 1/31/55
	Butt Weld, SMLS or ERW	Butt Weld, SMLS or ERW	SMLS or ERW

The table in PG&E's standard addresses all diameters in service on PG&E system and was developed from extensive research into PG&E's historical engineering standards regarding pipe used in PG&E's system.

The following describes how this four-inch excerpt of the table is employed in situations where the seam type for a pipe element on a PFL is unknown.

1. PG&E's historical standards show that four-inch diameter pipe used up until Jan 30, 1955 was either butt weld (BW), seamless (SMLS) or electric resistance weld (ERW).
2. If the purchase date for an unknown section of pipe is known to be on or before Jan 30, 1955, it is possible that BW pipe could have been used, and since BW is the most conservative longitudinal seam assumption due to its 0.6 joint efficiency factor, BW pipe is selected as the conservative assumption. Field investigation is performed if it is required to further characterize the seam type.

Once the seam type has been identified, the corresponding joint efficiency factor from PG&E's Table 4 below can be employed. These factors are consistent or more conservative than those in 49 CFR 192.

Table 4. List of Joint Efficiency Factors

Longitudinal Seam Type	Joint Efficiency Factor
Double Submerged Arc Welded (DSAW)	1.0

Longitudinal Seam Type	**Joint Efficiency Factor**
Seamless (SMLS)	1.0
Electric Resistance Welded (ERW)	1.0
Electric Fusion Welded (DSAW)	1.0
Lap Welded (includes pre1967 spiral weld)	0.8
Single Submerged Arc Welded (SSAW) and AOSmith	0.8
Butt Welded	0.6
Unknown ≤ 4” dia	0.6
Unknown >4” dia	0.8

Similar process flow diagrams have been established for other unknown pipe specifications such as wall thickness and other pipeline components such as elbows, tees and reducers with unknown specifications. Additionally, each specification associated with a conservative assumption is identified within the PFL and the MAOP Validation Report (See Figure 26) for each component.

Technical Assessments to Develop Conservative Assumptions
Technical assessments were performed by engaging industry experts to obtain guidance regarding policy-related issues. A few examples are briefly described below.

Hoop Stress for Bevelled Ends in Butt Weld Joints:
Pipe and fitting weld joint design may include bevelling to reduce the wall thickness of the heavier wall component to match the bevelled end of the thinner wall component. PG&E engaged an industry technical expert to assess and provide guidance relative to the pressure design formula referenced in 49 CFR 192.105 to identify the appropriate wall thickness to use in this pressure design formula in situations where a transition weld detail results in a wall thickness smaller than the nominal wall thickness of the respective component.

Bell End Joints:
Certain segments of PG&E's transmission pipeline systems contain bell-bell-chill-ring and bell-and-spigot joints. PG&E engaged an industry expert to assess and provide technical guidance on the appropriate diameter to use in the basic pressure design formula referenced in 49 CFR 192.105.

Continuous validation of conservative assumptions
Empirical data gathered from field investigations, as well as from the data included in the PFL based on the records, are continuously compared against the guidelines contained in the reference manual for conservative assumptions. When inconsistencies are found, revisions to the guidelines for conservative assumptions are made and retroactively applied to prior assumptions to ensure the use of the most updated information.

3.4.1.3 Field Investigation of Pipeline Components

Field investigations to verify specifications for respective pipeline components are required for several reasons. An example would be a situation in which the most conservative assumption for a component specification results in a MAOP that is below the existing MAOP of record for the pipeline system, combined with the prospect of adverse impacts such as significant constraints to transportation capacity potentially resulting in uncontrolled customer outages due to a lower operating pressure. Excavations are also performed to establish standards for pipelines which were purchased in service from third parties or characterize the specifications of reconditioned or reused pipe.

Field verification involves job scoping for the proposed field investigation expenditure, environmental permitting and property owner notifications, potential pipeline operations clearance coordination, excavation, and various non-destructive testing and repairs as necessary. Approximately 41 field excavations to investigate various component specifications were performed in 2011, and several hundred additional field investigations are forecasted to occur in 2012.

A few example procedures employed for determining component specifications during field investigations are included below.

Determination of Diameter
A simple "Pi measuring tape" (calibrated/marked in diameter inches) is used to measure the circumference of the pipe, as permitted for new pipe in API 5L. Measurements are made and documented in at least two areas for each excavation and diameter.

Determination of Wall Thickness
Ultrasonic thickness measuring instrumentation is used to obtain measurements at 12 points around the circumference of the pipe at quarter points, per DOT 49 CFR §192.109).

Determination of Long Seam Type

Visual examination of the long seam weld after cleaning is sometimes sufficient for the purposes of identifying the long seam type. PG&E maintains detailed photographic references to support identification through visual examination, and the examination is performed by PG&E or contract subject matter experts with required operator qualifications.

PG&E has developed procedures for use in distinguishing between long seam types in situations where visual examination is not sufficient. For example, radiographic inspection of the long seam welds is used to distinguish between SSAW and DSAW long seams. PG&E has developed a comprehensive procedure for cleaning, preparing and radio-graphing long seam welds to safely achieve reliable results. During the process, magnetic particle and radiographic examinations of the weld are performed to ensure that no indications or anomalies have been exposed as a result of any surface preparation grinding which may have been performed. If indications or anomalies of concern are identified, further assessment may show the need for repairs.

Metallographic testing is also used to determine seam weld type. This testing is primarily used to distinguish between the various solid state welding processes such as electric resistance welded, flash, lap, and furnace butt. Magnetic particle and radiographic testing are also used on these seams to indicate relative quality.

Validation of Material Yield Strength
PG&E has been testing the use of non-destructive material strength tests to validate the use of conservative assumed values for yield strength. This approach is not used to establish or determine the yield strength nor is it viewed as a substitute for the tensile tests set forth in 49 CFR §192.107.

The automated ball indentation (ABI) process involves the progressive indention of a tungsten-carbide ball into the test media (pipeline exterior surface). The spherical indenter geometry allows for increasing strain with continued indentation depth. During progressive indentation, intermediate partial unloading steps are conducted until full test-penetration is completed. Upon completion, the recorded incremental load versus indention depth data is converted to plastic true stress and strain using empirical relations and elasticity and plasticity theories, and assuming interchangeability between compressive and tensile material properties.

Figure 17 below illustrates the elastic and plastic response of the pipe steel wall, when subjected to loading and unloading of the indenter until full test penetration is achieved.

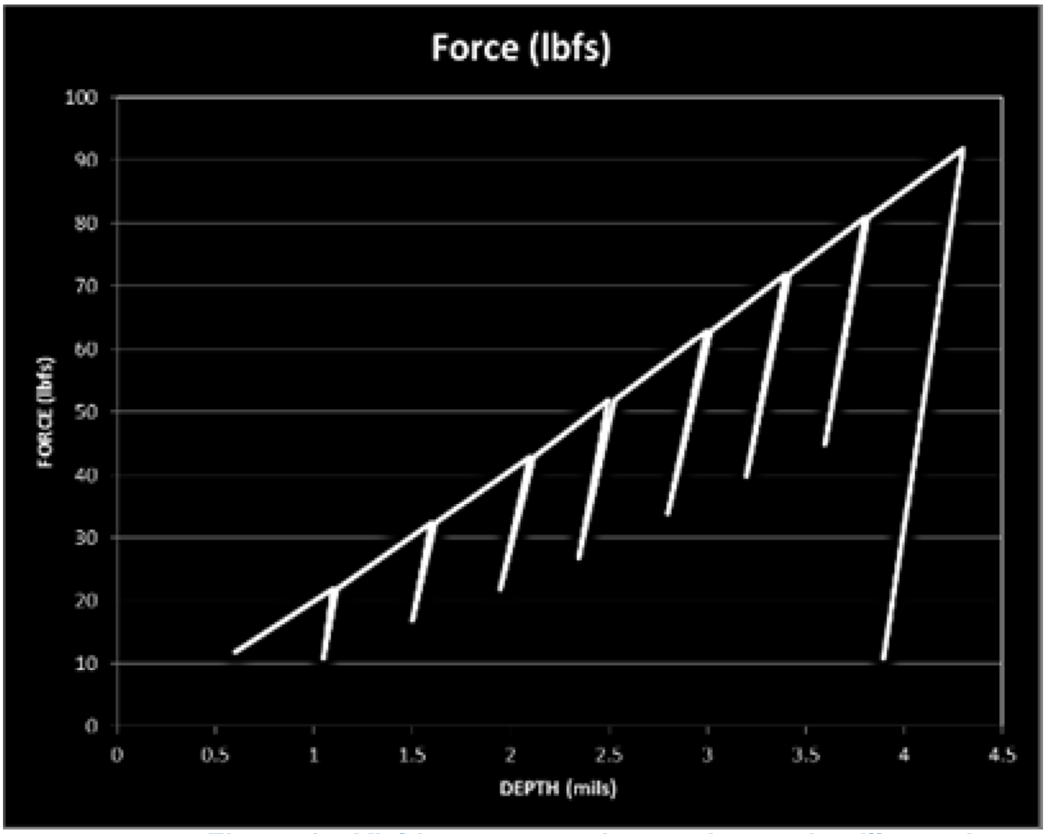

Figure 17. Yield stress non-destructive testing illustration

It should be noted that the ABI process is a surface measurement technique (with typical penetration of 0.005 inches), and is sensitive to surface residual stresses and micro-structural variability as well as pre-existing defects.

Several companies have conducted assessments of in-situ ABI tensile property predictions with API tensile-tested data; identified that ABI results could be affected by surface preparation; and determined that prescriptive surface preparation standards are required to minimize errors. PG&E is working with several firms that are developing equipment to apply this technology, and is conducting its own assessment regarding the merits of such technology for non-destructive determination and validation of material yield strength.

In addition to literature searches to take into account previous industry studies, PG&E has developed a test plan to demonstrate its applicability to the PG&E pipeline and this assessment is currently underway.

Excavation Example 1- Unknown pressure rating of pressure control fitting (PCF)

During the PFL build for an 8-inch Line 118A in Atwater, CA with a MAOP of 400 psig, two pressure control fittings were found on the drawings and associated documents, with the following contradictory information:

1. Purchasing documents (material requisition) associated with the 1947 construction job files stated that the four PCF fittings were purchased on the job on two separate material requisitions (Two PCF's in July 1947 and two in September 1947).
2. The first requisition states “022055 Fitting 8” PC 30”. The PG&E material code, 022055, referenced that it was a Series 15 ANSI 150 fitting (275 psig pressure rating). The 30 seemed to indicate a Series 30 ANSI 300 fitting (720 psig pressure rating).
3. The second requisite states “022096 Fitting 8” PC ser 30”. The PG&E material code, 022096, correctly referenced a Series 30 ANSI 300 fitting. Again “ser 30” seems to indicate a series 30 fitting.
4. There were no indications as to which requisition went to which location. Therefore a decision was made to excavate both crossings and verify the fitting pressure ratings.

The location of the field investigation excavation was in a waterway adjacent to a busy highway, making this an extremely challenging excavation (shown in Figure 18 below). However, the uncertainty based on the contradictory information and the prospect that two of the four PCFs could be ANSI 150 which was not adequate for the existing MAOP, resulted in the need to perform this field investigation and was the only feasible alternative.

Figure 18. Field Excavation Example 1 (Image 1)

The initial excavation revealed the cap of the PCF shown in the Figure 19 below.

Figure 19. Field Excavation Example 2 (Image 2)

PG&E standards from the 1930s and 1940s for PCF (shown in Figure 20 below) verified the PCF cap diameter and bolt count to be consistent with ANSI 300.

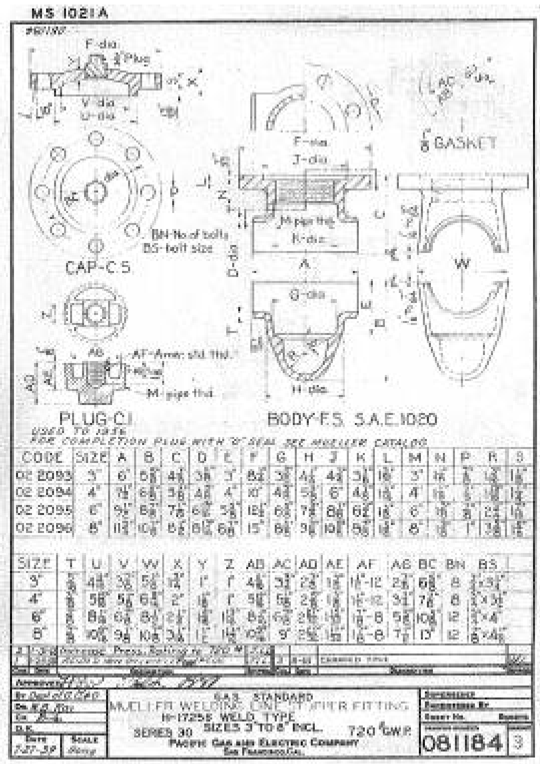

Figure 20. PG&E standard for Pressure Control Fittings

The cap thickness measured 1.2 inches, which was inconsistent with the 1.625 inch thickness found on the PG&E standards for ANSI 300 PCFs or blind flanges, and was domed which was also inconsistent with current ANSI 300 specifications. Figure 20 above shows the accompanying standard. The second excavation area for the other two pairs of PCFs found flat tops with thicknesses of 1.625”, consistent with ANSI 300, as well as an ANSI 300 diameter and bolt count.

Complete excavation was then conducted on the pair of PCFs with the domed caps and inconsistent cap thickness data. The PCFs found are shown in Figure 21 below. The conclusion drawn was that this pair of fittings was not standard ANSI 300 configuration, but potentially nonstandard field or shop fabricated assembly of an unknown manufacturer or pressure rating. PG&E then installed two new PCFs and piping, and removed these nonstandard fittings from service.

Figure 21. Field Excavation Example 1 (Image 3)

<u>Excavation Example 2 - Unknown Specification for Pipe Long Seam</u>
As-built drawings (bill of materials image shown in Figure 22 below) indicated that the pipe at a location on PG&E's Line 300 system which transports gas from south-western United States into PG&E service territory, was 34-inch diameter, seamless.

11-78

ITEM NO	QUANTITY	ORDER NO. DESCRIPTION	CATALOG OR DRAWING REFERENCE	OTHER DATA
				(OLD BM ITEM REF NO)
71		NOT USED		32
72	3	STRAP, 3/16" X 1" X 4" FLAT STEEL		33
73	~~0~~	~~NIPPLE, MUELLER SAVE-A-VALVE, MUELLER #H17490 2"~~	~~DETAIL "A"~~	34
74	~~0~~	~~RING, REINFORCING, 3/8" THICK X 4-1/2" (FOR ITEM 73)~~	~~O.D. 101~~	35
75	121 FT	PIPE, SEAMLESS STEEL, GRADE "B", 34" O.D., 5/16" WALL WRAPPED 314, 312		36
76	X 0	TEE, 34" X 34" X 12", BOTH ENDS BEVELED, DETAIL "J", ONE FOR 1/2" PIPE AND ONE FOR 5/16" PIPE Y=2'-6" AS PER DWG #281662		37

Figure 22. Field Excavation Example 2 (Image 1)

Historical manufacturing industry references for seamless pipe of this diameter were non-existent and are limited to 26" or less in diameter. As a result, this section of the pipe was excavated to perform a direct examination and characterize the long seam type. (Figure 23 below shows the pipe prior to resolution.)

Figure 23. Field Excavation Example 2 (Image 2)

The direct examination proved the pipe not to be seamless, but seamed. Further examination consisting of a series of radiographs of the long seam which confirmed that the seam type was DSAW, but also showed a linear indication in a portion of the seam which necessitated that approximately 10 feet of pipe must be replaced. Figure 24 below is one of the long seam radiographs taken during the investigation of this pipe, which established the seam type.

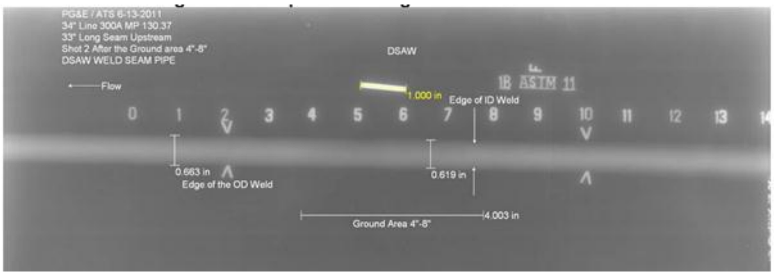

Figure 24. Field Excavation Example 2 (Image 3)

3.4.2 Upload of PFL Data into GIS platform

Once the PFL data is complete which includes the resolution of open issues regarding unknown specifications, the data from the PFL is uploaded into PG&E's new enhanced GIS platform. Unlike PG&E's existing GIS which is based on pipeline segments, this new platform is based on pipeline features, which allows much finer resolution for the pipeline system, and access to the specification data for each distinct pipeline component with an associated link to the source documents. Figure 25 below shows the display of the new enhanced GIS platform.

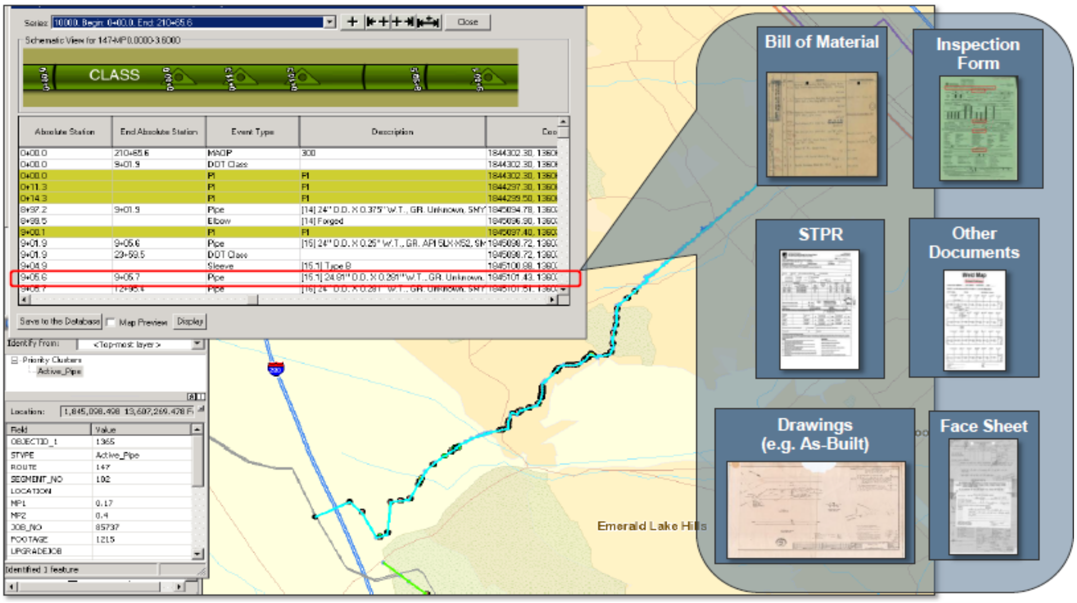

Figure 25 Consolidated PFLs, MAOPs, and all associated documents within a component-based GIS System of Record

This enhanced GIS platform uses the PFL data and performs calculations regarding the pressure limits for each component required for MAOP Validation, and allows engineering personnel to assess the implications of the pressure limits relative to existing operating pressure limits, as discussed in the following section.

3.4.3 MAOP Validation

Data in the completed PFL is used in the calculation of the MAOP that is conducted in accordance with Sections 49 CFR 192.105 and 192.619 for all pipeline components. Each component contains fields with the following values.

1. MAOP

Per design basis - often referred to as the design pressure; the maximum allowable pressure based on pressure design formula in 49 CFR 192.105, which relies on component material specifications combined with required design factors of safety. The §192.105 design formula for steel pipe is as follows: $P = (2\ St/D) \times F \times E \times T$

P = Design pressure in pounds per square inch gauge.

S = Yield strength in pounds per square inch

D = Nominal outside diameter of the pipe in inches.

t = Nominal wall thickness of the pipe in inches.

F = Design factor determined in accordance with §192.111 as shown in Table 5 below

Table 5. Design Factor based on Class Location

Class location	Design factor (F)
1	0.72
2	0.6
3	0.5
4	0.4

Additional details in §192.111 address these design factors for more complex circumstances than merely class locations, such as road crossings, or bridges, or compressor or regulating stations.

E = Longitudinal joint factor determined in accordance with §192.113. (Refer to Table 4 provided earlier in this paper)

T = Temperature derating factor determined in accordance with §192.115 as shown in Table 6 below.

Table 6. List of temperature derating factors

Gas temperature in degrees Fahrenheit	Temperature derating factor (T)
250 °F (121 °C) or less	1.000
300 °F (149 °C)	0.967
350 °F (177 °C)	0.933
400 °F (204 °C)	0.900
450 °F (232 °C)	0.867

An example of the MAOP Validation report is shown below in Figure 26.

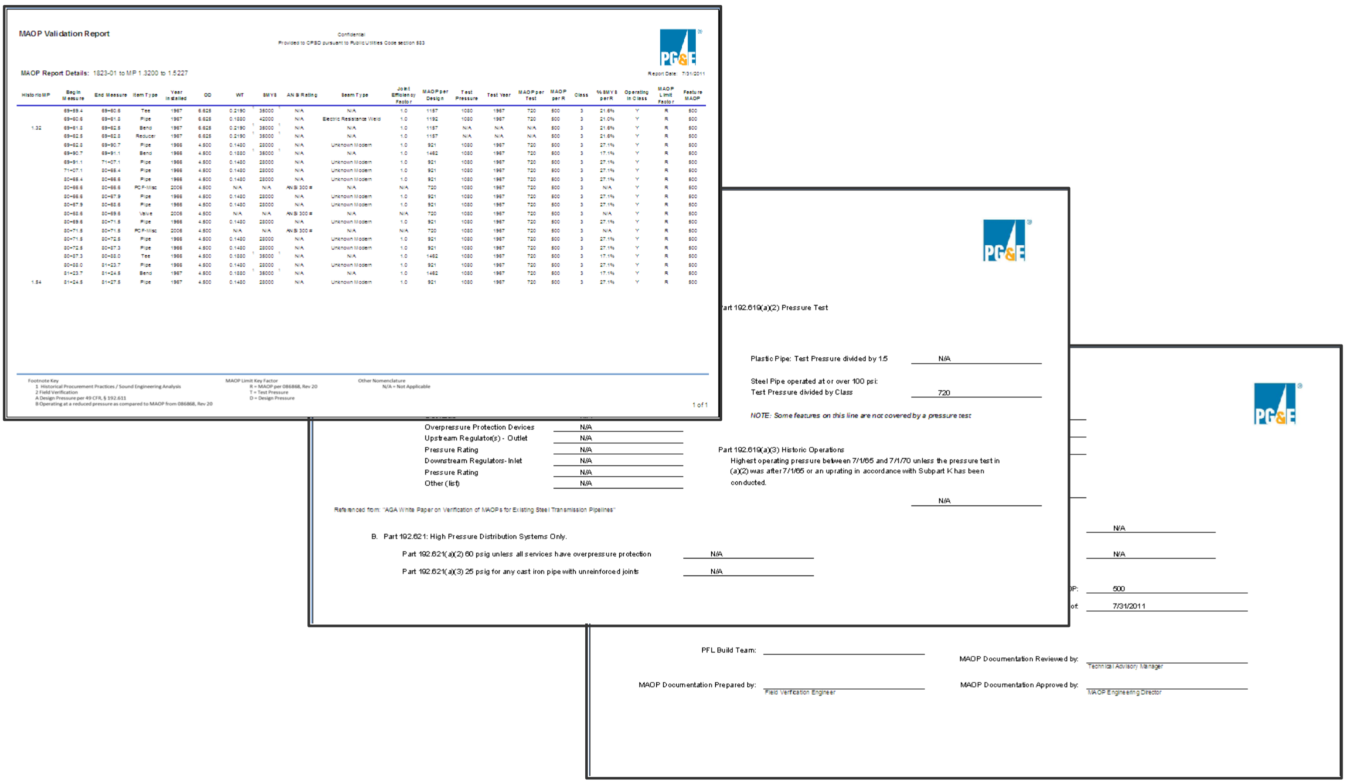

Figure 26. Sample of MAOP Validation Report

2. MAOP based on pressure/strength test - the pressure limit established as a result of the strength test pressure.

The CPUC code requirements for strength testing were identified in 1961 as part of GO112A. The test pressure is divided by the factor shown in Table 7 below to determine the MAOP based on strength test.

Table 7. Class location based factor for determining MAOP based on strength test

Class location	Factor
1	1.25
2	1.25
3	1.5
4	1.5

In 1970, federal code also adopted strength test requirements. Current strength test pressure limits in §192.619 are as shown in Table 8 below. The test pressure is divided by the factor in Table 8 below to determine the MAOP based on strength test. 49 CFR §192.14 sets forth requirements for conversion of steel pipe previously used in service not subject to §192 (not natural gas transportation service).

Table 8. Factors used to determine the MAOP based on strength test

Class Location	Factors		
	Installed before (Nov. 12, 1970)	Installed after (Nov. 11, 1970)	Converted under §192.14
1	1.1	1.1	1.25
2	1.25	1.25	1.25
3	1.4	1.5	1.5
4	1.4	1.5	1.5

3. MAOP of record - the current pressure limit as documented in PG&E's engineering standard for the respective pipeline section.

The MAOP per design and MAOP per strength test are compared with the MAOP of record and if either of these MAOPs is less than the MAOP per record, additional field action is performed. Field actions can include further investigation consisting of performing excavations and direct examinations, pressure reductions, strength tests, or replacement of pipe or an associated pipeline component. Additionally, the MAOP Validation process includes an analysis to verify the component is operating within the assigned class location in accordance with 49 CFR §192.611. The MAOP calculations and analysis are subjected to technical quality assurance by an independent third party.

MAOP of the pipeline or the respective component cannot be raised based on the results of the validation process nor can the MAOP be established by this process.

Transmission pipelines with pressure limits established previously by means other than strength test in the State of California are subject to such a test in accordance with 49 CFR 192 Subpart J to validate the ability of the pipeline to operate safely at its MAOP.

3.4.4 Quality Assurance

Quality Assurance (QA) is an independent function on the MAOP project with a purpose to perform periodic assessments and sample testing in order to ensure the end product of each process meets intended requirements. A team of approximately 10 people perform assessments and periodic sample testing on each step in the process; from Plat Walk through the MAOP Validation Process (see Figure 27 below)

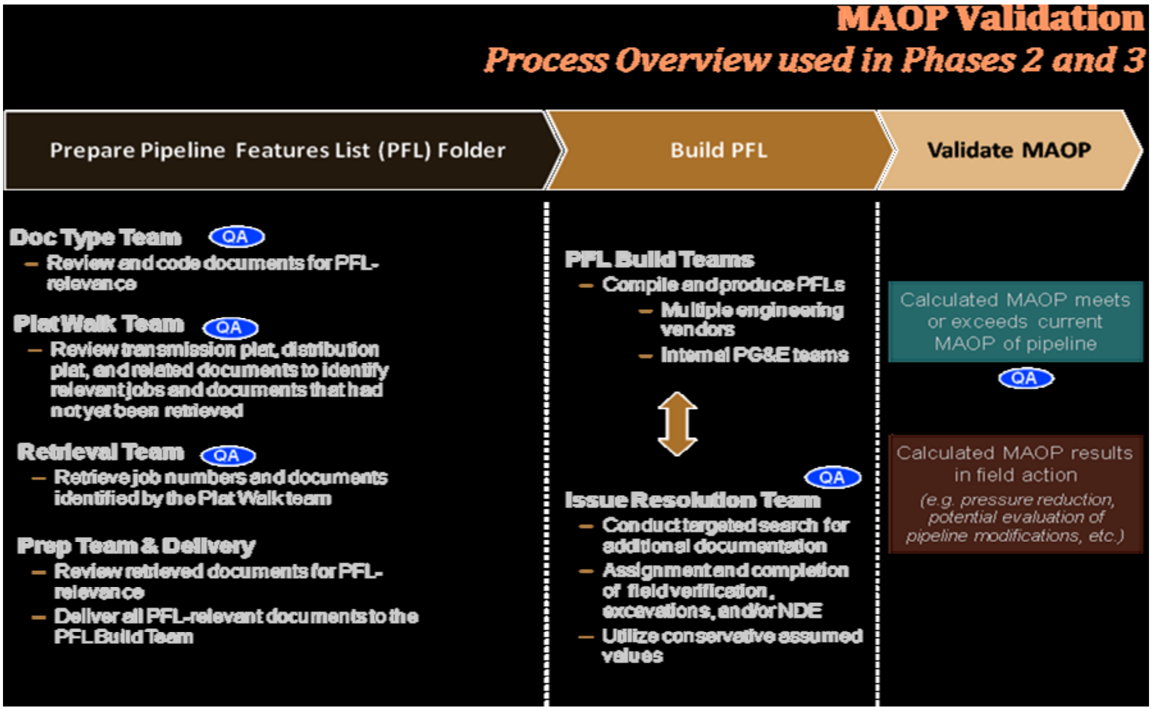

Figure 27. Quality Assurance efforts during MAOP validation

As the MAOP Project "ramped up" resources to meet the project deadlines, process steps (Plat Walk, Retrieval, Issue Resolution, etc) were designed, staffed, implemented, and began producing information and data needed to verify the MAOP of PG&E's gas transmission pipelines. As these process steps were designed and implemented, the QA team followed the approach described below (modelled after ISO 9001:2008).
The approach to QA for the Project consists of the following high level activities:

- Assess whether the Project uses formally defined and documented processes, to include Quality Control (QC)
- Assess whether those processes are designed and implemented using documented specifications, and that those specifications flow from an appropriate governing standard
- Apply QA oversight by performing scheduled QA assessments of Project processes, procedures, QC activities, and results in order to assess the existence of and compliance with the documented processes, procedures, and QC activities
- Assess the effectiveness of the procedures and controls in producing the desired results
- Perform QA assessments of specific Project activities as requested by Project leadership
- Report to Project Leadership the results of the QA assessments, including recommendations for corrective actions

These QA activities validate that the process produces outputs as expected (documents, data, or calculations). The project also uses ample testing data to verify the comprehensiveness and robustness of QC for each process by comparing the results of the QC to the QA sample testing results. The results of the periodic testing drive root cause analyses, and corrective action discussions. The QA team can propose corrective action, and is the primary management resource for follow up on the implementation of the corrective action.

A rigorous process exists to test each process step to provide as much data to the build teams for review as possible. A sample of the completed PFLs is tested on a weekly basis to ensure consistency in the application of standards, data interpretation, and the application of conservative assumptions. It should be emphasized here that the acceptable level for errors on a PFL that result in a less conservative MAOP for a particular PFL is zero percent. The Project team places safety as the foremost priority, and therefore the QA team seeks the most conservative response in each of its testing criteria.

3.4.5 Strength Testing

In 2011, PG&E conducted 97 hydrostatic tests for 163.6 miles of transmission pipeline without a prior strength test with characteristics most similar to the pipeline segment that ruptured in San Bruno. The objectives of this hydrotest program are to prove the absence of flaws that could cause the pipeline to rupture at its MAOP, and establish a predictable margin of safety at the MAOP. It was necessary to conduct the program almost entirely outside the period of peak demand (three-month winter season) since a typical pipeline segment would be out of service for a period of time between 13 and 30 weeks to accommodate a hydrotest.

Figure 28. Hydrostatic Test Set up

The management of hydrotest water required substantial resource and time commitments. The pipe cleaning process was required to meet relatively stringent water discharge requirements. The staging of the tank system as shown above in figure 28 required a large footprint, which in turn required considerable lead time to arrange.

PG&E's portable gas supply equipment was deployed to maintain supply to customers during pipeline outages. These consisted of a wide variety of sizes of compressed gas cylinder trailers, as well as liquefied natural gas trailers and vaporization systems (shown in Figure 29 below) which PG&E has had on hand to preserve service during routine construction operations and to provide supply in isolated locations during emergency outages or winter peak demand periods.

Figure 29. Equipment PG&E uses to preserve service during hydrostatic testing

The largest non-core customers and electric generating plants were the most impacted because PG&E's portable supply equipment is not large enough to support the largest customer loads. Hydrotesting often involved working in tight quarters (as shown in Figure 30 below), since some of PG&E's transmission pipelines are located in city streets.

Figure 30. Hydrostatic testing in process

Ruptures occurred on two of 97 hydrotests.

Figure 31. Hydrotesting results

The rupture shown in Figure 31 above was located at the tip of a large gouge caused by third-party mechanical damage visible at the edge of the rupture to the left of the employee. The rupture occurred at 550 psig, during a test to establish a 400 psig MAOP.

The second rupture occurred at 998 psig during a test to establish a 757 psig MAOP. The rupture occurred at 95% SMYS and consisted of a seam failure. The seam failure is currently undergoing analysis.

Figure 32. Hydrotesting Analysis Results

One test created a small leak in the middle of the deep corrosion pit, shown in the bottom right corner of figure 32 above. All three of these pipelines were repaired and successfully retested.

Additionally, on June 9, 2011 the CPUC issued a decision requiring all California gas transmission operators to develop a plan to pressure test or replace all gas transmission pipelines that do not have complete records of a prior test conducted to modern standards, and directing the gas utilities to address the expanded use of in-line inspection tools and automatic gas shutoff valves. PG&E filed PSEP in response to the CPUC's Decision (D) 11-06-017 on Aug 26, 2011.

PG&E will continue the strength testing program in 2012 and beyond with an estimate that is in excess of 750 miles over the course of the next three years focused on pipelines primarily in HCAs without a prior strength test.

4 Results

4.1 Summary

PG&E believes that its records verification MAOP validation project represents an unprecedented effort in the U.S. natural gas industry, due to the level of detail and quality involved in this work, combined with the aggressive timeline in which it is being accomplished.

Through end of December 2011, PG&E has validated MAOP for approximately 1,826 miles of HCA pipelines containing approximately 2,300 PFLs. As part of the associated field verification effort, PG&E performed over 40 excavations and identified and addressed over 18 anomalies at these excavation locations, which included corrosion and pitting, seam flaw and third-party damage on various pipeline components. Seven excavation locations required pipe/elbow replacements and the remainder have been repaired without a need for replacement. In addition, PG&E performed 10 pressure reductions to allow for additional system safety margin where the current MAOP of the respective pipelines could not be validated.

As a result of this work, PG&E is committed to sharing lessons learned, findings and recommendations with other natural gas providers as they work to build or strengthen their asset management programs. It is in the collective interests of all utilities, regulators and other stakeholders to work together to improve public safety.

4.2 Applications of MAOP Validation

Peninsula Pipeline System Pressure Reduction and Restoration

PG&E reduced the maximum operating pressure (375 psig) of its transmission pipeline system on the San Francisco Peninsula by 20% shortly after the San Bruno rupture. Figure 33 below shows PG&E's network in the San Francisco Peninsula.

Figure 33. PG&E Gas network in San Francisco Peninsula

This pipeline system is critical for meeting anticipated winter gas demand on the San Francisco Peninsula. Absent this capacity which would be lost as a result of a 20% reduction in maximum operating pressure, curtailment of core and non-core customers could occur, the volume of which is dependent on the severity of the weather. In October 2011, PG&E submitted a filing to the CPUC to restore pressure on one of the critical pipelines in this system, L101 and the associated cross-tie pipelines. In support of its request, PG&E

completed the following tasks, which were driven by the results of the process described earlier in this paper for PG&E's Records Verification & MAOP Verification Project:

1. MAOP Validation
    a. Determined which pipelines and associated components located in high consequence areas had traceable, verifiable and complete pressure test records
    b. Built PFL's to validate the MAOP of each respective pipeline component
    c. Conducted field inspections of pipeline components in order to obtain unknown or verify assumed data
2. Pressure Testing
    a. Conducted pressure tests on portions of the system for which a pressure test record could not be located in accordance with 49 CFR 192 Subpart J
    b. Verified that all components classified as transmission per 49 CFR §192.3 had a pressure test in accordance with the regulations at the time the test was conducted

CPUC granted PG&E's request to increase the maximum operating pressure on these facilities to 365 psig in November 2011.

4.3 Key Takeaways from PG&E's experience

Key Challenges identified during the project:

1. Initial planning for project resources was difficult as a baseline for the required duration and effort to complete each step in the process was unavailable, and required continuous resource rebalancing resulting in suboptimum resource use.
2. Clustering of segments to complete high priority sections of pipeline first (in accordance with the required schedule) resulted in completing PFL's in a very fragmented manner as opposed to a more efficient continuous manner for a single pipeline in its entirety.
3. A constraint on the availability of qualified pipeline engineers has kept the build and issue resolution teams on the critical path.
4. While the initial focus on overall document scanning rather than targeting critical documents performed in Phase 1 would have been ideal long-term, the targeted scanning approach was necessary to meet project deadlines. Since many of the targeted job folders needed to be rescanned during Phases 2 and 3 or eventually for a complete digital database, this duplicative scanning effort made the overall process efficiency less than ideal.
5. The extremely aggressive schedule did not allow advance development and utilization of an appropriate comprehensive GIS/Data Management system for the end to end process to allow for efficient execution of work.

Key Project lessons learned:

1. Retrieve all documents from one field office at a time to ensure the most efficient use of retrieval resources. Digitize all job records to ensure immediate access to job documents for anyone involved in the project including the field office.
2. Box all documents and ship them to a centralized location for scanning and storage as a superior approach to ensuring that all documents are digitized and available upon request, as opposed to fragmenting this effort across multiple locations.
3. Implement a robust barcode tracking system to ensure that you can easily determine the location of any hard copy job folder and digitized document if necessary.
4. Organize job documents based on an established taxonomy and upload all images to a digital database to complete the development of a digital archive of all documents across the company.
5. Execute the PFL Build on a line-by-line approach based on an established priority by

pipeline for optimal efficiencies within the overall process.

6. Bundle required record validation field investigations and excavations into larger contracts as much as possible for more efficient and cost effective execution.

5 Summary/Conclusions

There is general agreement between natural gas operators that records verification and MAOP validation are valuable. There are differing opinions about the degree of work and level of detail that are necessary. Based upon PG&E's experience, there is strong acknowledgement within the company that records verification and MAOP validation are foundational to having a sound integrity management program, are necessary in decision making, and are critical to operating a safe natural gas transmission system.

PG&E has fully embraced the NTSB's important recommendations and is united with the regulators in a collective determination to prevent a tragedy like the San Bruno accident from ever happening again.

Among the steps taken to address the NTSB's concerns, PG&E will verify the maximum allowable operating pressure on nearly 2,100 miles of natural gas pipelines as of the end of January 2012, updated its emergency response plan to reflect industry best practices, and is implementing data management systems to ensure its pipeline records are traceable, verifiable and complete.

PG&E has done an unprecedented amount of work in 2011 to improve the safety of its gas system and is encouraged by this progress and recognizes that there still remains much to be done.

PG&E's Pipeline Safety Enhancement Plan, which was submitted in 2011 for approval to the CPUC, details many of the improvements under way or planned over the next few years. The plan incorporates and goes beyond the NTSB's recommendations, calling for continued pipeline replacement and retrofits.

Since the San Bruno accident, PG&E has concentrated on modernizing its operations, benchmarking against industry-leading utilities, and changing its corporate culture to demonstrate "safety first" both in words and in deeds. New yet seasoned leaders have been hired to champion the effort, recognize behaviour and actions that support this ideal of a "safety first" culture and to lead by example. Slowly, critics and customers are seeing PG&E demonstrate its sincere commitment to public and employee safety.

6 Glossary of Terms

49 CFR 192: Federal Code, defined by PHMSA, focused on the minimum federal safety standard requirements for the transportation of natural and other gas by pipeline.

A-Form & Leak Test/Report: An A-Form is submitted when pipe is inspected, tested, or repaired and can be used to document the installation of weld patches to repair leaks or third-party damage. Leak Tests/Reports are summaries of a leak test or leak survey that contain pre-test pipeline data, as well as actual test data.

AGA: American Gas Association. Founded in 1918, the AGA represents more than 200 local energy companies that deliver clean natural gas throughout the United States. AGA serves as a voice and facilitator in promoting the safe, reliable and cost effective delivery of natural gas in the United States.

ANSI: American National Standards Institute. It oversees the creation, promulgation and use of thousands of norms and guidelines that directly impact businesses in nearly every sector.

ASA: American Standards Association– 1920s through 1960s predecessor to ANSI.

ASME: American Society of Mechanical Engineers. A not-for-profit membership organization that enables collaboration, knowledge sharing, career enrichment, and skills development across all engineering disciplines, toward a goal of helping the global engineering community develop solutions to benefit lives and livelihoods.

ASTM: American Society for Testing and Materials

Bill of Material: Documents containing itemized lists of pipeline features (components with attributes which differ from adjacent components) used on a project and typically include item number, quantity, and description of each component.

CAISO: California Independent System Operator.

CFR: Code of Federal Regulations

Cluster: Group of combined pipeline segments that make up a section of pipeline for which the PFL is to be created.

Component: A discrete part of a physical pipeline system, such as a section of pipe or a fitting (tee or elbow, valve, etc.). It is used interchangeably with "Feature" in this paper.

CPUC: California Public Utilities Commission, state regulatory agency that regulates privately owned electric, natural gas, telecommunications, water, railroad, rail transit, and passenger transportation companies in California. The CPUC serves the public interest by protecting consumers and ensuring the provision of safe, reliable utility service and infrastructure at reasonable rates, with a commitment to environmental enhancement and a healthy California economy. CPUC regulates utility services, stimulates innovation, and promotes competitive markets, where possible.

Class Location: Areas defined in 49 CFR §192.5 which distinguish between levels of population density, as follows: in the immediate vicinity of a pipeline.

- Class Location 1: any class location unit that has 10 or fewer buildings intended for human occupancy.

- Class Location 2: Any class location unit that has more than 10 but fewer than 46 buildings intended for human occupancy.
- Class Location 3: Any class location unit that has 46 or more buildings intended for human occupancy or where the pipeline lies within 100 yards of either a building or a small, well-defined outside area that is occupied by 20 or more persons at least 5 days a week for 10 weeks in any 12-month period.
- Class Location 4: Any class location unit where buildings with four or more stories above ground are prevalent.

Detail Sheet: Document type that typically follows Face Sheets and contains expenditure details for the proposed or completed work.

DSAW: Double Submerged Arc Welded. Description of the longitudinal seam in pipe manufacturing. This seam is welded with an arc welding process in which the arc is submerged in a sold powdered flux shield, on both the inside and outside of the pipe wall.

Construction Drawing: Drawings or schematics useful to the construction phase of a project (typically include pipeline components such as pipe segments, valves, regulators, filters, etc.). These are also referred to as "As-Built Construction Drawings".

Detail Drawing: Comprehensive drawings depicting certain pipe components within or outside of a pipeline system.

Distribution Plat Map: Maps of distribution pipelines that detail the distribution system network and individual service lines (in a plan view) that connect neighbourhoods or small buildings to transmission pipelines. Transmission pipelines are also included on these maps.

Drawing-Transmission Plat: Maps of transmission pipelines based on an integration of various construction drawings and include information on components such as pipe, elbows, tees, or other pipeline components.

Drawing-Vicinity: Documents that depict pipeline position in relation to adjacent geographical features.

ECTS: Enterprise Compliance Tracking System.

EDMS: Engineering Document Management System.

EFW: Electric Fusion Welded.

Engineering Materials Memo (EMM): Documents used to request quotes from suppliers to obtain pipeline components needed to complete specific projects.

ERW: Electric Resistance Weld.

Face Sheet: Document type that summarizes information about the project (including the proposed location and type/amount of material to be installed or completed work).

Feature (used in "pipeline feature): See definition for Components.

Gas Invoice: Document from a third party that requests payment for gas system services and/or equipment, which may contain data regarding pipeline features or services provided by including detailed material specifications for items purchased for gas pipeline work.

Gas Journal Voucher: Written authorizations prepared for financial transfers between accounts in order to distribute interdepartmental charges, reclassify, adjust, or correct financial data for gas-related items.

Gas Material Requisition: Documents that consist of requests for purchase of pipeline components, including pipe and associated specifications (e.g., diameter, wall thickness, material yield strength) and other pipeline components such as elbows, tees and reducers and their associated specifications.

Gas Service Record (GSR): Description of small jobs performed on customer service pipelines such as installation of taps to tie in a customer to a distribution feeder main or transmission line.

Gas Transport Tag: Document containing information about the delivery to or removal from a construction project or site, of pipeline components.

GIS: Geographic Information System. Data system designed to capture, store, manipulate, analyze, manage, and present all types of geographically referenced data. In the context of PG&E's gas pipeline system, its GIS contains transmission pipeline location information that can be displayed geographically, and contains corresponding pipeline data (e.g., pipe diameter, wall thickness, material strength/specification, strength test information, installation date) which can be referenced from the geographic display.

HCA: High Consequence Area. Defined in 49 CFR §192.903 as an area established by one of the methods described in paragraphs (1) or (2) as outlined below. PG&E has used method 1 to define HCAs for the purposes of the Records Verification & MAOP Validation Project.

METHOD (1) An area defined as a class 3 or 4 location, or any area in a Class 1 or Class 2 location where the potential impact radius is greater than 660 feet (200 meters), and the area within a potential impact circle contains 20 or more buildings intended for human occupancy; or any area in a Class 1 or Class 2 location where the potential impact circle contains an identified site.

METHOD (2) The area within a potential impact circle containing 20 or more buildings intended for human occupancy, or an identified site.

Identified site means each of the following areas:

(a) An outside area or open structure that is occupied by twenty (20) or more persons on at least 50 days in any twelve (12)-month period. (The days need not be consecutive.) Examples include but are not limited to, beaches, playgrounds, recreational facilities, camping grounds, outdoor theatres, stadiums, recreational areas near a body of water, or areas outside a rural building such as a religious facility; or

(b) A building that is occupied by twenty (20) or more persons on at least five (5) days a week for ten (10) weeks in any twelve (12)-month period. (The days and weeks need not be consecutive.) Examples include, but are not limited to, religious facilities, office buildings, community centres, general stores, 4-H facilities, or roller skating rinks; or

(c) A facility occupied by persons who are confined, are of impaired mobility, or would be difficult to evacuate. Examples include but are not limited to hospitals, prisons, schools, day-care facilities, retirement facilities or assisted-living facilities.

Potential impact circle is a circle of radius equal to the potential impact radius (PIR).

Potential impact radius (PIR) means the radius of a circle within which the potential failure of a pipeline could have significant impact on people or property. PIR is determined by the formula $r = 0.69*$ (square root of $(p*d^2)$), where 'r' is the radius of a circular area in feet surrounding the point of failure, ‘p’ is the maximum allowable operating pressure (MAOP) in the pipeline segment in pounds per square inch and ‘d’ is the nominal diameter of the pipeline in inches.

Note: 0.69 is the factor for natural gas. This number will vary for other gases depending upon their heat of combustion. An operator transporting gas other than natural gas must use section 3.2 of ASME/ANSI B31.8S–2001 (Supplement to ASME B31.8; incorporated by reference, see §192.7) to calculate the impact radius formula.

H-Form: Document containing data (e.g., assessment of pipe and pipe coating condition, soils and related cathodic protection factors, depth of cover, etc.) recorded during the exposure of a section of buried pipe for inspection, maintenance or repair. .

Hydrostatic Test – Subjecting a pipeline section to internal pressure above the intended MAOP, to confirm the integrity of the pipe, and the factor of safety between the test pressure and the MAOP. Water is used so that in the event a leak or rupture occurs, the pipeline segment pressure decreases very quickly, minimizing the risks from the damage that results.

Index Drawing: Drawing typically for larger stretches of pipe that shows the areas covered by the Transmission Plat maps

Inspection Test Form: Documents that provide insight to the periodic inspections or tests completed on pipeline components including pipe, elbows, tees, reducers and other related components.

Joint Efficiency Factor: Also known as longitudinal joint factor, this is a term used to compensate for the characteristic strength of the longitudinal weld seam in pipe. A value of less than 1.0 denotes a derating of the strength of the pipe relative to longitudinal seams with strengths at least as high as the pipe wall itself.

MAOP: Maximum Allowable Operating Pressure for a pipeline component defined in accordance with 49 CFR §192.619.

Mill Test Report: Document that includes the pipe material properties and the results of the strength test performed at the manufacturer prior to shipping it to PG&E. A test report for pipe typically includes test results for material chemistry, tensile strength, material hardness and describes the testing method used.

Miscellaneous Document: Reserved for all documents that cannot be identified as one of the other PFL document types and includes pipe or feature/component specification required for PFL preparation.

MOP: Maximum Operating Pressure for a pipeline system. The lowest feature-level MAOP in a pipeline system, which limits the maximum pressure for the system. For example, if a pipeline system includes a feature such as a valve with a 720 psig MAOP, and other components have a MAOP at or above 800 psig, the MOP for the pipeline system will be 720 psig.

NDE – Non-destructive Examination – Analysis technique used to evaluate properties of material for in-situ pipeline components without the use of destructive testing. Used by PG&E in the determination of specifications for pipeline features while the feature remains in operation.

Non-PFL Document: Document not needed for PFL preparation.

NTSB: National Transportation Safety Board. Federal government agency charged with determining the probable cause of transportation accidents and promoting transportation safety, and assisting victims of transportation accidents and their families.

Operating Pressure Chart: Circular graphs which record pipeline operating pressure readings continuously over time. Time durations are typically one, three or seven days.

Operating Pressure Log: A tabular presentation of pipeline operating pressure over time. Contains the same pressure information as operating pressure charts for discrete time intervals instead of continuous time.

Other Drawing: Drawings and schematics that cannot be identified by any of the other drawing document types.

PCF: Pressure Control Fitting – Equipment which can be welded onto a pressurized pipeline in service, to provide the capability to block flow in the pipeline, or to add a branch connection to the pipeline without removing the pipeline from service.

PFL: Pipeline Features List. Tabular array of data for a pipeline section, containing all pertinent data needed to support the assessment of design and operating pressure limits. Examples of data fields include installation date; feature type (e.g., pipe, fitting, valve, etc.); material specifications (e.g., diameter, wall thickness, steel grade etc.), strength test information and other related information.

PHMSA: Pipeline and Hazardous Materials Administration. Agency of the federal government responsible for regulating and ensuring the safe and secure movement of hazardous materials by all modes of transportation, including pipelines. Develops regulations and conducts inspections of US pipelines to confirm performance in accordance with regulations.

Pipeline Segment: Section of pipeline boundaries that are assigned a unique identifier with consistent material and other relevant properties (e.g., wall thickness, yield strength, strength test, risk characteristics, installation conditions, etc.) Pipeline segments have been the basic building block used by PG&E's current version of the geographical information system and its integrity management program.

Plan & Profile Drawing: Drawings that contain two views, plan (bird's eye view) and profile (cross-section), of a particular geographic area pertaining to a pipeline project.
Plat: A map, drawn to scale, showing the location of gas transmission and distribution pipeline locations, and showing some land ownership information.

PSEP: Pipeline Safety Enhancement Plan. Following the San Bruno Incident on Sep 9, 2010, the CPUC issued a decision on June 9, 2011 requiring all California gas transmission operators to develop a plan to pressure test or replace all gas transmission pipelines that do not have complete records of a prior test conducted to modern standards, and directing the gas utilities to address the expanded use of in-line inspection tools and automatic gas shutoff valves. PG&E filed the "Pipeline Safety Enhancement Plan (PSEP)" in response to the CPUC's Decision (D) 11-06-017 on Aug 26, 2011.

RCM: Reliability Centred Maintenance Model (RCM) is a process used in managing asset failure and its consequence through the full life cycle of assets.

Regulator Data Sheet: Documentation of pressure regulating equipment specifications, test information, operating set points, and other related information used to support operating and maintenance history of the pressure regulator.

SMLS: Seamless. Pipe manufactured without a longitudinal weld seam.

SMYS: Specified Minimum Yield Strength. The specified minimum yield strength for steel pipe manufactured in accordance with a listed specification. This is a common term used in the oil and gas industry for steel pipe used under the jurisdiction of the United States Department of Transportation. It is an indication of the minimum stress a pipe may experience that will cause plastic (permanent) deformation.

Soils/Trenching Information: Document type that contains information regarding soil characteristics pertinent to trenching and the installation of a pipeline.

Specifications: Document type that details the manufacturing procedure and material requirements for pipeline components.

SSAW: Single Submerged Arc Welded. Description of the longitudinal seam in pipe manufacturing. This seam is welded with an arc welding process in which the arc is submerged in a sold powdered flux shield, on a single side (typically outside of the pipe wall).

STPR: Strength Test Pressure Report. Document which contains critical information regarding the requirements of the strength test (e.g., minimum and maximum test pressures, minimum test duration, pipe material specifications and other related information) and the information recorded during the test prior to making the pipeline system operational. This document is a certification of the design requirements and the results from the execution of the field test.

STPR Chart: Circular graph which records pipeline test pressure readings continuously over time, for the duration of the pressure test. .

STPR Log: A companion document to the STPR and/or STPR chart and contains tabular data consisting of time and corresponding pressure readings.

STPR Sketch: A companion document to the STPR (i.e., often drawn on the reverse side of the STPR form) which provides a non-scale graphical depiction of the section of the pipeline that was strength tested.

Uprate Procedure Document: Documents that detail the process of increasing the MAOP on a pipeline section in accordance with code requirements (49 CFR §192 Subpart K), and which includes a description and purpose of the uprate, specifications of the pipeline, date of uprate, other requirements, etc.

Valve Maintenance Record: Form which contain specifications (e.g., manufacturer, model, pressure rating, other relevant information) and maintenance and inspection history (dates on which maintenance was performed, mechanic who performed the maintenance and any relevant maintenance issues) for pipeline system valves.

Walk: The process established by PG&E in which teams review and follow the transmission pipelines on distribution plats and transmission plats foot-by-foot, to identify features and any other information (e.g., job numbers, specifications, installation notes) required to develop the PFL for the associated pipeline section.

Weld Map: Schematic diagrams showing the locations of welds on the pipe segment, and containing information regarding the weld (e.g., weld type, welder identification, welding supervisor).

X-Ray Document: Document containing results of x-ray examinations for a specified weld, or welds segment of pipe. Summary documents include the total number of welds tested and total number of welds rejected.