CPUC Meeting Materials

Weekly Non-Destructive Examination Program Updates

March 14, 2014

Discussion Topics

- PG&E/SEA Alignment
  - L-114
  - Extent of Conditions for TCI Inspections
  - NDE Program Enhancements
  - NDE Program Validation Protocols/Extent of Conditions (LLNL)

- Completed Activities To Date

- Next Steps
  - Schedule
  - Immediate Needs

TCI Validation

- See presentation dated 3/7/2014 for past items
- Completed all 43 committed digs/re-inspections (Appendix I)
- Leak Survey details
  - Leak Survey began on 600 miles of identified Gas Transmission pipeline (12/2/2013)
  - February Leak Survey Finalized :
  - Zero leaks found on weld (Girth or Long Seam)
  - PG&E requesting authorization to suspend "monthly" leak surveys (Appendix II)
- LLNL finalized "Review of PG&E Proposed Dig Plan" (Appendix III)
  - Established 3 alternatives
    - Re-inspection/Digs with 5% error
    - Re-Inspection/Digs with 2% error
    - Comprehensive analysis of weld inspections through existing film
      - PG&E working to secure LLNL's services for Comprehensive analysis
        - Contract routing for signature

[1]Activity progress/completion is discussed in the Completed Activities To Date section
[2]Dates are contingent on weather, permit, and/or construction schedules

LLNL Recommended Alternative

- Comprehensive Analysis Alternative
  - Analyze all film for 488 non-compliant welds
  - Establish conditional probability of weld flaws being present by utilizing rejection information from construction
  - Utilize probability of weld flaws within population of 488
  - Utilize non-compliant weld film and establish total % of area that can detect
  - Determine population of welds requiring re-inspection
  - Dig/Re-inspect welds requiring it
    - Speculation that many of the required digs will be of the 43 PG&E has already re-inspected
    - Will need to confirm once analysis is complete
  - LLNL issued summary report on 3/13/2014 (Appendix III)

[1]Activity progress/completion is discussed in the Completed Activities To Date section
[2]Dates are contingent on weather, permit, and/or construction schedules

Completed Activities to Date

- See 2/7/14 presentation for items prior to 2/1/14
- Excavated/Tested/Passed 43 welds as of 3/11/14:
  - 5 welds on L-132
  - 12 welds at Vernalis Station
  - 2 welds at 8 Mile Rd Pressure Limiting Station (PLS)
  - 4 welds on L-108 (MLV38.1)
  - 4 welds at Gateway Generating Station
  - 8 welds at L-108 (MLV38.17)
  - 3 welds on DFM-1616
  - 3 welds on L-331A (WV-7)
  - 2 welds on L-302W (Appendix I)
- Completed L-114 Final Report
- Created Maps of pipeline segments to be Leak Surveyed as a result of L-114 Findings
- Completed 3 monthly Leak Surveys of 600 miles of pipeline
  - Zero leaks on welds have been found

Next Steps

- High Level activities within the next 6 Weeks
  - See 2/7/14 presentation for prior items:
  - Finalize Comprehensive Analysis of TCI Data Set
    - Establish required digs (3 months)
    - Finalize digs/re-inspections (TBD)
  - Establish LLNL contract update for analysis associated with recommended alternative for TCI Validation
    - LLNL to perform analysis of all film and establish recommendations for re-inspection
    - PG&E has contract in progress currently
  - Issue revised standards/Testing/Training for NDE Program (4/15/2014)

Appendix I

Summaryof WV-8A Re-Inspections

Technical Services, Inc.
P. O. Box 721139, Houston, Texas 77272-1139

Redacted

www.ndttechnicalservices.com

SUMMARY AND ASSESSMENT OF EOC – RE-INSPECTION PERFORMED ON GIRTH WELDS

In accordance with the approved PG&E Inspection Test Plan (ITP), on March 11, 2014 a re-inspection utilizing radiographic examination with AGFA D5 film was performed on two (2) girth welds at verification dig site WV-8A (Hershey Junction) in Dunnigan, CA. Once each of the welds were radiographed they were "fingerprinted" (weld features compared against original images) to verify that the original radiographic film images of the weld matched the images of the re-inspected girth weld.

The following weld numbers were re-inspected:

Original Weld Id Number		Re-inspection Weld Id Number
Location: 8A	W-127	W-127-RI
Location: 8A	W-128	W-128-RI

The following were the results of these-inspections:

Weld Number: W-127-RI Comments: Weld matched fingerprint and weld was determined to be acceptable to API 1104, 20th edition.

Weld Number: W-128-RI Comments: Weld matched fingerprint and weld was determined to be acceptable to API 1104, 20th edition.

Location 8A contained two (2) 20 in. OD girth weld identified as Weld #127 & 128. A copy of WIX's Radiographic Testing Inspection report indicating the results of their evaluation of welds examined are attached.

This summary completes the evaluation and documentation of the re-inspections performed on the two (2) identified girth welds on the WV-8A project in Dunnigan, CA.

Let me know should you require any additional information concerning these reviews and approvals.

Respectfully,

Redacted

President
ASNT Level III – 2820
ACCP Professional Level III

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Date 3/11/2014 Page 1 Of 1
Radiographic Report or Control # Rig G - 01
Customer PG&E
Address
Customer's P.O. Number
Job Location Hershey Junction, Dunnigan L302W
Job Number 42070345 WV-08A
Item Description 20" Girth Welds
100% Insp. ✓ Spot Insp. ______ Percent ______

Nondestructive Inspection Report

Piece or Joint #s	Weld Number	Film No.	Acc	Rej	Defect Code	Comments
20" x .500" w	127 RI	3	✓			
20" x .500" w	128 RI	3	✓			

Work Summary

Amount	Description
2	Travel Hours ______ # Persons
0930	In Time 1300 Out Time
3.5	Work Hours
	Standby Hours
5.5	Total Hours
	Per Diem ______ # Persons
	Mileage One Way ___ Round Trip ___
2	Weld 20 in. dia. ______ Weld ______ in. dia.
	Weld ______ in. dia. ______ Weld ______ in. dia.
	Weld ______ in. dia. ______ Weld ______ in. dia.
6	Film 26" x 90 Type D5
	Film ______ x ______ Type ______

Technique Date/Procedure Qualification

Inspection Specification API 1104
Acceptance Standard 20th
RT Procedure No. RT7 Shooting Sketch (RSSS) D
View: DWE SWV Source Ir192 Curies 95
Physical Source Size: .106x.09 Effective Focal Spot: .139
Pb Screens: Front .005 Center NA Back .01

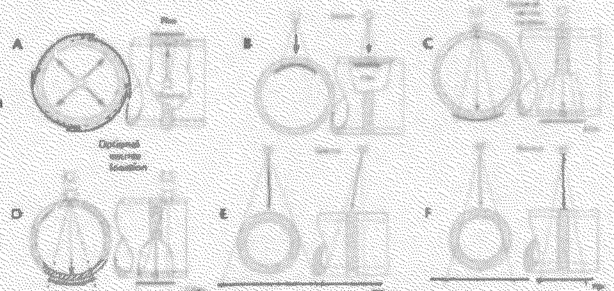
Dia. 20 Material Type: X52 Thickness: .5 Reinf.: .125
SFD: 20 Source To Obj.: 19.5 IQI Essential Wire: 1B-8 / .016
Exp. Time: 2 min. 30 sec. Dev. Time: 5m @ 68 deg.
Film Manufacturer: Agfa Speed: D5 No. of Exp. 3 Film 3
Geometric Unsharpness (Ug): .004 Avg. Density: 2.6

Dia. ______ Material Type: ______ Thickness: ______ Reinf.: ______
SFD: ______ Source To Obj.: ______ IQI Essential Wire: ______
Exp. Time: ______ min. ______ sec. Dev. Time: ______ @ ______ deg.
Film Manufacturer: ______ Speed: ______ No. of Exp. ______ Film ______
Geometric Unsharpness (Ug): ______ Avg. Density: ______

Dia. ______ Material Type: ______ Thickness: ______ Reinf.: ______
SFD: ______ Source To Obj.: ______ IQI Essential Wire: ______
Exp. Time: ______ min. ______ sec. Dev. Time: ______ @ ______ deg.
Film Manufacturer: ______ Speed: ______ No. of Exp. ______ Film ______
Geometric Unsharpness (Ug): ______ Avg. Density: ______

Defect Code

BT - Burn Through
C - Crack
CV - Root Concavity
CX - Root Convexity
DT - Drop Through ✓
ICP - Inadequate Cross Penetration
IF - Incomplete Fusion
IP - Incomplete Penetration
PD - Inadequate Penetration Due to High-Low
OX - Oxidation ✓
P - Porosity
SL - Slag Lines
SI - Slag Inclusions
UC - Undercut
TI - Tungsten Inclusion



1 Redacted Level II
2 Level I

The person signing this document represents that they have the authority to sign on the behalf of the customer. This report does not guaranty or warranty the condition of the materials tested. Western Industrial X-Ray, Inc. is not liable for any interpretation of results or losses attributable to any testing performed. There is no warranty for these services. Any liability is limited to the amount paid for the services in question. Final film interpretation is the responsibility of the customer.

Redacted Date 3-11-2014

Report Form WIX-101

Appendix II

PG&E Weld Quality Leak Survey Recommendation

PG&E Weld Quality Control
Leak Survey Recommendation

Background

In 2012, PG&E began reviewing its Non Destructive Examination (NDE) Program against best industry practices. As part of the PG&E Gas Operations NDE Process Improvement Initiative, the Gas Quality and Improvement (QE&I) Group requested the NDE Services Group of PG&E's Applied Technology Services (ATS) to perform job observations of NDE vendors. During the performance of one of these unannounced job observations at a project site on L-114 in Brentwood, CA, the PG&E ATS NDE inspector observed TC Inspection (TCI) performing Radiographic Testing (RT) in a noncompliant manner to both the referenced code (American Petroleum Institute) API 1104, 20th edition and their own method procedure.

Actions Taken

PG&E took immediate action, which included ceasing all work with TCI and conducting an in-depth examination of all weld inspections completed by TCI from 2012-2013. PG&E is currently working with Kiefner and Associates, as well as Lawrence Livermore National Labs (LLNL), to do a thorough review of records and to determine the best approach to verify quality. This effort will give PG&E actionable data to identify potential weld inspection gaps and develop a plan to resolve them.

In addition to the statistical work on inspection quality assessments being undertaken by LLNL, PG&E has also evaluated the quality of inspection records for 3,755 welds inspected by this vendor dating back to year 2010. PG&E has also evaluated the radiographic film quality and inspection coverage, finding potential inspection quality issues with 488 of those, as outlined below.

1) 137 welds - Inspections performed with the 2 exposures instead of 3
2) 127 welds - Inspections performed where the exposure angle is in excess of 120 degrees
3) 224 welds - Inspections performed with missing weld coverage

The CPUC found PG&E to be in violation of 49CFR192.243 and API 1104 for the 224 welds and PG&E was fined $8.1 million as a result of the violation. PG&E has since excavated and evaluated the safety and the quality of inspection for 43 welds, beginning with the worst quality radiographs. These welds met criteria for API 1104 and revealed that the lower quality of radiographs has not missed any defects that would be of a size that would cause an increased pipeline safety risk or be out of compliance with API 1104.

PG&E has also initiated a monthly leak survey of pipe potentially impacted by a lack of adequate documentation or quality control practices for weld inspections. PG&E determined the scope of the leak survey by considering the following factors:

- <u>Pipe Installation Year</u>: Code requirements for radiography of welds were not implemented until July 1962. As a result, pipe installed prior to 1962 is not subject to the radiography quality control issues being addressed by this work. Therefore, only post-1962 pipe was considered for inclusion in the leak survey.

- Land Movement: In discussing construction-related threats to pipeline integrity, ASME B31.8S-2004, the consensus industry standard for managing system integrity of gas pipelines and incorporated by reference into 49 CFR 192, states that "the existence of these construction related threats alone does not pose an integrity issue. The presence of these threats in conjunction with the potential for outside forces significantly increases the likelihood of an event." The primary threat for outside forces associated with girth welds is interaction with areas of potential land movement. Therefore, only pipe with a vulnerability to land movement was included in the scope of the survey.
- Class Location: All Class 3 and 4 pipe meeting the prior criteria are included in the scope of the survey due to population density near the pipeline.
- High Consequence Areas (HCAs): HCAs in Class 1 and 2 locations are also included in the scope of the survey due to population near the pipeline.

As a result of these criteria, approximately 600 miles of pipe were included in the scope of the survey. PG&E has conducted a leak survey of these pipelines for 3 months, and has not found any we leaks during these surveys.

Recommendation

The supplemental leak survey was initiated to ensure the safety of the public near PG&E's pipelines. While PG&E felt a leak survey was appropriate measure to ensure the safety of the public in the short term, leak survey is not the most effective method to understand the overall risk associated with PG&E's welding quality control process for the following reasons:

- A leak survey only detects an issue with a weld after it has already failed, which does not educate the scope of the potential issue as effectively as a random sample of welds would.
- Since the leak rate on welds is very low (less than 1% of overall leaks), it is unlikely that the leak survey will produce significant results on the state of the welds associated with this pipe.
- Since the issue being addressed is a quality control and an inspection issue and not a construction issue, conducting a leak survey does not address how well the quality control on the weld was conducted or documented, even if it identifies an issue with the weld itself.

Based on the results of the leak survey conducted so far, the ongoing efforts with Kiefner and LLNL, and the findings so far from the in-field evaluations, PG&E believes it is appropriate to suspend these future "monthly" leak surveys pending results of the additional studies underway. If any welds excavated through the study indicate an immediate safety issue, PG&E will re-initiate the leak survey process.

Appendix III

Review of PG&E Proposed Dig Plan

LAWRENCE LIVERMORE NATIONAL LABORATORY

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Review of PG&E Propose

K. Lenox, A. Lamont, G. Bo
and L. G. Glascoe

February 2014

OFFICIAL USE ONLY

May be exempt from public release under the Freedom of Information Act (5 U.S.C. 552), exemption and category:

Exemption 4, Commercial Information

Department of Energy review required before public

Date: February 6, 2014

Name/org: Lee G. Glascoe, Engineering

Guidance: CG-PAR-2 (August 1999)

Technical Report
submitted to Pacific Gas and Electric Company

Official Use Only

Disclaimer

This work performed under the auspices of the U.S. Department of [illegible]
Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

Review of PG&E Proposed

Kristin P. Lennox, Alan Lamont, Grant Boquet and Lee

Executive Summary

A variety of methods, intended to ... assess and bound risk ... welds that were subjected to incomplete inspections at ... in ... assessed. A comprehensive analytical approach ... mitigate risk more ... than the ... based ... inspection ... based methods. ... underlying ... how to ... that contractor inspected ... inspections were discovered. PG&E proposed statistical sampling based ... dig... part of ... remediation strategy, and requested that the ... plan and present possible alternatives.

From a purely technical standpoint, ... proposed ... due to ... size considerations, and there are limits on ... that can be made due to the lack of random ... addressed by changing the sample size calculation and ... fixing the statistics may be less critical than two more ... First, the confidence bound ... PG&E's ... proposed ... (95% confidence ... that there are ... defective ... in the population) ... weak, particularly ... for welds with ... inspe... industry standards, considered unusually high. The ... proposed ... analysis ... largely does not make ... of information about the set ... the form ... compliant ... radiography ... This ... unnecessarily pessimistic view of the risk situation.

This document contains three proposed ... sample size ... the calculation method. The first alternative does not ... more ... a comprehensive assessment of weld defect ... probability for ... suggested. This ... existing ... radiographic information as well as ... about replacement rates for defective welds ... This method can be carried out in parallel with ... rapidly provide an improved assessment of the state ... assessment is complete, the decision can be made as ... weld re-inspection is necessary. ... purely statistical in nature and ... designed ... problems regarding the original sampling ... sampling ... consistent with original sampling strategy, they would not leverage any ... information and the default sample sizes would provide ... flaw rates within the set.

1 Introduction

In 2013, PG&E discovered that TCI, one of its NDE [illegible] compliant radiographic inspections of welds. PG&E has pursued approaches to remediating this problem, including a comprehensive inspection for Line 114, where the issue was originally discovered, and the re-evaluation of radiographs from all TCI inspections from 2012 as well as from 2010–2011. Of TCI's 3,780 inspections, 641 were found non-compliant to radiographic inspection. Of these, 153 were then reinspected, leaving 488 welds with non-compliant inspection information.

In addition to reviewing the existing radiography for th[e] [illegible] chose to physically reinspect a sample of these. This preliminary sampling plan, described in "TCI Weld Validation and Inspection Report, Preliminary" to [illegible] considering these 488 welds with non-compliant inspection data by TCI. It does not consider, for example, the non-compliant welds on Line 114 which were originally radiographed by a different contractor.

This document contains a review of the preliminary sampling plan, as well as several alternatives that might have improved performance relative to various metrics. The review of the preliminary PG&E plan is contained in Section 2. Section 3 details a different sampling plan with the potential to provide lower bounds on risk by using information about the whole welds. Section 4 [illegible] possible alternatives, two sampling based approaches that are more rigorous than the preliminary plan. Section 5 contains conclusions and a comparison of the requirements and anticipated results of the proposed plans.

2 Preliminary PG&E Inspection Plan

2.1 Plan Description

PG&E's Quality and Improvement group used a Gaussian [illegible] proportions with finite sample correction to determine the [illegible] used for the TCI Inspection Validation project. The for[mula] [illegible] example, Cochran[1]:

$$n = \frac{\dfrac{z^2 p(1-p)}{d^2}}{1 + \dfrac{1}{N}\left(\dfrac{z^2 p(1-p)}{d^2} - 1\right)}$$

[1] Cochran, *Sampling Techniques*, 3rd Edition. John Wiley and Sons. (1977) p. 7[illegible]

where n is the sample size, N is the total population size, p is an estimate of th
event probability, d is the desired precision (half the width)
for the proportion, $z_{\alpha/2}$ is the normal distribution quantile where
1-α is the desired confidence level.

The PG&E analysis used a 95% confidence level (α=0.05, z=1.96), precision of ... (
and initial estimate p=0.02, which were described as standard
company for assessing construction projects. ... size of
compliant inspections (N=488), excluding those ... and rounding up to the
answer, this formula gives a sample size requirement of

The 43 welds inspected were chosen according to a ... approach, and included all welds with inadequate inspectio
welds with the largest gaps in film coverage, ...
exceeding 120% length requirement.

2.2 Evaluation of Preliminary Plan

There are difficulties in applying the PG&E proposed methodology in the
current situation. The first is that the confidence inter
approximation; it is not expected to hold in cases
numbers in the smaller class. In this case, the smaller class consists
welds, and it is anticipated that none will be obs
approximation is not recommended.

The choice of precision is also noted. It is noted that
chosen value indicates that the 95% upper bound for
the sample is expected to be 4% using this methodology. This numb
high relative to the percentage of unacceptable welds that would
completely uninspected pipe.

This analysis does not account for the existing informa
incomplete inspection data, for the 488 welds. In most
radiographs can convey at least some information about
potentially be used during the risk assessment process
required inspections.

Finally, the strict interpretation of the 95% confidence
sampling, which is not being employed in this case.
exchanging the current risk based sampling scheme with
but the fact that the confidence statement does not

The remainder of this document presents three alternative
mitigation plans. The first would require additional analysis
radiographic data, but might result in both a smaller

SB_GT&S_0070196

inspections and a lower bound on risk. The latter
assumptions of the sampling (95% confidence, 5% bound on
and are purely statistical in nature. That is, they
quality based on incomplete radiographic information.

3 Alternative Comprehensive Risk-Based Method

There are two difficulties with using purely statistical approaches to address this situation:

1) They may not provide a low enough bound the set of 488. In particular, the current sta the flaw rate (5%) that is significantly much higher than the replacement rate of welds at install time. Since believe that improper welding was linked to imp is also reason to believe that the flaw rate i prior to any inspection. Therefore, demonstrating a lower bound coul require a substantially higher sample size than th
2) Statistical bounds rely on key assumptions about out. Specifically, any member of a population sho probability of being selected, or that all items equal probability of exhibiting a flaw. Since welds dig plan according to problems in radiography, neither of these assumptions is satisfied. Flaws specifically are more likely in welds where the original radiography was poo with flaws that were not repaired are those due to poor radiography. Therefore, sampling based flawed radiography is likely to produce biased re *results will probably be conservative.* If PG&E and their r satisfied with the 5% bounding criteria and the assumptions, then the suggested solution is a completely random sample for the risk-based procedure.

If, however, PG&E or their regulators desire a lower there are alternative methods to a purely statistical ap to provide stronger conclusions. Purely statistical approaches, as noted previ do not account for the partial information about welds inspection data. Compliant inspections do not necessarily have probability of finding flaws; they have a reduced (or pos finding flaws for some portion of the circumference of determined that compliant inspection had a very high chan significant weld defects, may then not need to be inspected. In case, only welds where the inspection is likely to is present, should be considered for reinspection.

This analysis would require additional information, including the percentage of defective welds detected at installation and a detailed analysis of the welds where the radiography … certified in spite of imperfect radiography. While this … approach would be able to generate a substantially lo… it can be pursued in parallel with existing dig pla… benefit may be assessed relatively quickly.

Such analysis would calculate the conditional probability of a w… the underlying rate of flaws at installation time and … radiographic information is available. The probability of a … particular pipe can be calculated using Bayes' rule:[2]

$$\Pr(\text{flaw present} \mid \text{no flaw detected}) = \frac{\Pr(\text{no flaw detected} \mid \text{flaw present})\Pr(\text{flaw present})}{\Pr(\text{no flaw detected})}$$

where Pr(A|B) is the probability of A being true … is true. The probability of missing a flaw that is presen… present)) can be bounded by analyzing the radiographs, and determining … how much of the weld lacks inspection … flaw coverage … can be estimated by considering the replacement rate … similar lines, and the … probability of detection … the combina… probability that the weld is not flawed … and the fa…

For a simplified example, imagine a weld with 90% … from a line with a 2% … The probability of … the weld being flawed is:

$$\Pr(\text{flaw present} \mid \text{no flaw detected}) = \frac{(1-0.9)(0.02)}{0.98+(1-0.09)(0.02)} \approx 0.002$$

That is, we would expect only 0.2% of such weld… collection of completely uninspected welds. Note that the … notional, and that a … full analysis … information about the pos… on a girth weld where weld … flaws … information … that influenced either the flaw rate or detection proba…

A comprehensive analysis would determine conditional flaw probability … every weld in the data set, and then an expected … entire collection. If … enough, and there is a pos… would be less than one, … inspection …

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[2] See, e.g., Devore, *Probability and Statistics for Engineering and the Sciences* … Brooks/Cole. (2004) p. 82

expected flaw [illegible] higher than PG&E and their regulators
with, then the welds with the highest conditional prob
prioritized for inspection. Due [illegible] to the [illegible] selected for re
inspection were chosen based on the poor quality of
it is expected that the [illegible] high priority also

4 Alternative Statistical Methods

While a purely statistical [illegible] approach [illegible] of all available
of welds, it may be preferred [illegible] regulat
two purely sampling based approaches providing confidence
with the original analysis [illegible] limitations [illegible] these
methods in terms of sampling [illegible] assumptions are also n

4.1 Finite Sample Analysis

The total population size is 488 welds [illegible] it is
than [illegible] welds) is acceptable, [illegible] hypergeometric [illegible]
determine how many welds must be checked. The firs
probability [illegible] observed given [illegible] sample [illegible] tota
population [illegible] where the maximum acceptable number of
(x=25) is assumed to exist. This probability can be

$$\Pr(\text{no observed failures} \mid x \text{ failures total}) = \frac{\binom{N-x}{n}}{\binom{N}{n}}$$

where $\binom{N}{n}$ [illegible] from [illegible] total is
population of N [illegible] size [illegible] determine the n [illegible] sample size [illegible] number
of flawed [illegible] the population below [illegible] 95% [illegible] acceptable level
confidence, one identifies n [illegible] smallest [illegible] calculated probability
observing no failures [illegible] 0.05 [illegible] the minimum sa
size [illegible] equivalent analysis [illegible] 43 [illegible] samples [illegible] either 90% conf
that the flaw [illegible] 95% confidence that the flaw
6.5%.

This method is analogue [illegible] original PG&E sample s
calculation. Disadvantages of this method [illegible] need for completely
sampling for all welds in order for [illegible] confidence

[3] Cochran, *Sampling Techniques* [illegible] John Wiley and Sons. (1977) p. 5

fact that a 5% flaw rate is possibly greater than
time. This analysis would [illegible] only [illegible] improperly [illegible] inspected
have a higher defect rate than welds that have n
the maximum allowable flaw rate to 2% (fewer than
population) would increase the required sample size to 126, [illegible]
completely random sampling [illegible] the confidence statement [illegible] to
any flawed welds [illegible] observed in the sample, this analysis woul
modification.

4.2 Binomial Analysis

An alternative analysis method [illegible] assumption that all improp
inspected welds have an equal probability of being fla
require an equal probability of sampling every weld.
does not leverage the finite [illegible] size of the sample.

As [illegible] finite sample, [illegible] begin with [illegible] probability [illegible]
flaws will be observed from a population [illegible] p, with a
The formula for this probability is:

$$\Pr(\text{no observed failures} \mid \text{failure probability } p) = (1-p)^n .$$

As in the hypergeometric example, [illegible] size [illegible] minimum [illegible] the
below [illegible] found by identifying [illegible] the smallest [illegible] no failure pr
less than [illegible] 0.05 [illegible] 95% confidence that the population flaw
5%, the minimum sample size has [illegible] population [illegible] 95% [illegible] flaw
rate does not exceed 2%, the minimum sample size
observed in the sample, a slightly different analysis is
hypergeometric example, this method is [illegible] designed [illegible] to make
population of all improperly inspected [illegible] than just the 488
data set.

Given that welds have [illegible] inspection [illegible] selected [illegible], the
equal flaw probability assumption in this case is [illegible] likely
the improperly inspected welds with extremely poor radiog
more likely to have flaws than those with better
welds with more comprehensive [illegible] radiography [illegible] detected at
time.

5 Conclusions

This document presents and explains [illegible] potential assumptions
remediation strategies for the 488 [illegible] compliant weld inspections [illegible] non
preliminary sampling [illegible] put together by [illegible] two alternative

[4] Cochran, *Sampling Techniques*, [illegible] John Wiley and Sons. (1977) p. 5

sampling plans and comprehensive risk-based approach. The potential advantages and disadvantages of the solutions are presented.

The two statistical approaches (Section 2) ... the assumptions of the sample size calculation, but do not ... assumptions make ... asymptotic ... anticipated low rate of weld defects. A sample size ... size of the Section 2 ... give a 95% confident 5% u... defect rate with 54 samples observed ... with no ... sampling ... flawed ... assumption is key for this analysis, and does not ... plan. An alternative that assumes equal probability of observing ... a flaw for any ... Section 2.2 ... would require ... welds ... samples observed flawed welds to conclude with 95% confidence ... rate for improperly inspected welds is no greater than ...

In the context of ... the ... use of ... sampling approaches ... is strictly rigorous; ... random ... sampling is not being carried ... advisable in this case. Although the strategy of inspecting ... radiographic records violates the assumptions of both prop... approaches, the results are ... likely ... to be conserv...

Of potentially greater concern is the 5% upper bound ... records provided ... in Table 1 ... the installation and discussions with ... subject matter experts, one would not expect ... to see ... that had never been inspected. The bound may therefo... However, purely statistical approaches would require exhaustive ... substantially lower bounds. This is due to the fact ... approaches do not take into account partial information ... form of ... -compliant ... non-inspection data. Given that even an ... carries some information about weld quality, there is ... rate ... could be ... more effectively by carefully analyzing the ... inspection data along with weld quality information from ... This is ... the ... (Section 3) ... the authors consider most suitable ... problem. This strategy ... carried out in parallel with the exis... welds, and the likely benefits assessed ... -based ... quickly. ... analysis is complete, the potential need for additional ...