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

NDT 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

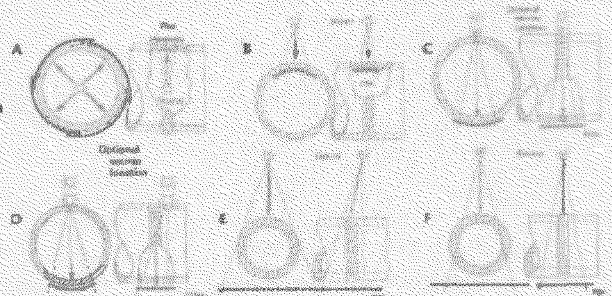
Dia. 20 Material Type: X52 Thickness: .5 Reinf.: .125
SFD: 20 Source To Obj.: 19.5 IQI Essential Wire: 1B-8 / .016
Exp. Time: 2 min. 30 sec. Dev. Time: 5m @ 68 deg.
Film Manufacturer: Agfa Speed: D5 No. of Exp. 3 Film 3
Geometric Unsharpness (Ug): .004 Avg. Density: 2.6

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



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Level II

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.

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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.

3/13/2014

- 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 an 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

Review of PG&E Propose

K. Lennox, A. Lamont, G. Bo

and L. G. Glascoe

February 2014

Technical Report

submitted to Pacific Gas and Electric Company

Disclaimer

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

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 approaches based on inspection ... based methods. The underlying question is how to set ... that contractor inspected ... compliant ... incomplete inspections were discovered. PG&E proposed statistical sampling based dig part of a remediation strategy, and requested that the plan and present possible alternatives.

From a purely technical standpoint, the proposed ... due to sample 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 mo... First, the confidence bound PG&E's proposed analysis (95% confidence ... that there are ... defective welds in the population) ... weak, particularly ... rate of 5% for welds with ... by inspe... industry standards, considered unusually high. The proposed analysis ... largely does not make use of known information about the set ... the form ... compliant ... This ... unnecessarily pessimistic view of the risk situation.

This document contains three proposed ... sample size ... the ... calculation method. The first alternative does not ... a comprehensive assessment of weld defect probability for ... suggested. This ... existing ... 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 ... problems regarding the original sampling ... consistent with ... 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 ND[illegible] compliant radiographic inspections of welds. PG&E [illegible] pursued approaches to remediating this problem, including [illegible] inspection [illegible] for Line 114, where [illegible] originally [illegible] the evaluation of radiographs from all TCI inspections [illegible] 2013 as well as 2010 2011. Of [illegible] inspections, 641 were found compliant to radiographic inspections. Of these, 153 [illegible] were then inspected, leaving 488 welds with non-compliant inspection information.

In addition to reviewing the existing radiography for [illegible] chose to physically [illegible] of [illegible] preliminary sampling plan, described in "[illegible] the Validation and Inspection [illegible] Technique" to considering these 488 welds with non-compliant inspection [illegible] by TCI does not consider, for example, [illegible] Line 1[illegible] originally radiographed by a different contractor.

This document contains a [illegible] preliminary sampling plan, [illegible] as well as several alternatives that might [illegible] improved performance relative to various metrics. [illegible] review of the preliminary PG&E plan is contained in Section 2. Section 3 [illegible] sampling [illegible] different [illegible] the potential to provide lower bounds on risk by using [illegible] information about the whole welds. Section [illegible] possible alternatives [illegible] two sampling based [illegible] approaches [illegible] more rigorous [illegible] preliminary plan [illegible] the Section [illegible] contains conclusions [illegible] comparison of [illegible] the requirements and [illegible] anticipated results of the [illegible] 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[illegible] example, Cochran[1]

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

[1] Cochran, *Sampling Techniques*, 3rd ed. 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 estimate, z is the normal distribution $\alpha/2$, where for 1-α is the desired confidence level.

The PG&E analysis used a 95% confidence level (α=0.05, z=1.96), precision of d=0.1, and initial estimate p=0.02, which were described as standard company for assessing construction projects. Using the population size of compliant inspections (N=488), excluding those for and rounding to the answer, this formula gives a sample size requirement of n=43.

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, inspection exceeding 120° angle requirement.

2.2 Evaluation of Preliminary Plan

There are difficulties with 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 desired precision is also important. It is noted that chosen value indicates that the 95% upper bound for the sample is expected to be 6%, using this 4% 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. The first would require additional analysis radiographic data, but might result in both a smaller

inspections and a lower bound on risk. The latter
assumptions of the straight (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 difficulties with using purely statistical approach 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% may be that is substantially 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 being done, 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 weld
dig plan according to problems in radiography, neither
of these assumptions is likely. Flaws 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 *overpredict the observed*
results will probably be conservative. PG&E and their
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. Non-compliant inspections do not necessarily have
probability of 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, they may not need to be inspected. In
case, only welds where the inspection is likely to
is present, should be considered for re-inspection.

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

Such analysis would calculate the conditional probability of a w[eld] the underlying rate of flaws at installation time and radiographic information is available. The probability of a particular pipe can be calculated using Bayes' T[heorem][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[t] present)) can be bounded by reading the radiographs, and determining how much of the weld lacks inspection at the flaw coverage probability can be estimated by considering the replacement rate similar lines, and the approach is to detect the combina[tion] probability that the weld is not probably flawed and the fa[...]

For a simplified example, imagine a weld with 90% from a line with a 2% The placement of rate probability 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 probability analysis information about the pos[...] on a girth weld where weld flaws are more informational likely that influenced either the flaw rate or detection proba[bility]

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

4 Alternative Statistical Methods

While a purely statistical 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] presented [illegible] limitations [illegible] the
methods in terms of sampling 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] analysis [illegible] can be used [illegible]
determine how many welds must be checked. The firs
probability *no flawed welds* [illegible] observed given [illegible] sample [illegible] tota
population N=488 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
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 [illegible] n [illegible] smallest [illegible] calculated probability
observing no failures [illegible] 0.05[3] [illegible] the minimum sa
size [illegible] equivalent [illegible] analysis [illegible] 43 [illegible] sample [illegible] either 90% conf
that the [illegible] 95% confidence that the flaw
6.5%.

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

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[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 only be detected improperly 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, and would still
completely random sampling of the confidence statement to h
any flawed welds were observed in the sample, this analysis woul
modification.

4.2 Binomial Analysis

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

As with the finite sample, we begin with the probability that
flaws will be observed from a population 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, the minimum sample
below is found by identifying the smallest n for which the failure pr
less than 0.05 for 95% confidence that the population flaw
5%, the minimum sample size is 59. For a population flaw
rate does not exceed 2%, the minimum sample size
observed in the sample, a slightly different analysis is
hypergeometric example, this method is designed to make
population of all improperly inspected welds, rather than just the 488
data set.

Given that welds have been selected for re-inspection based on risk, the
equal flaw probability assumption in this case is likely
the improperly inspected welds with extremely poor radiog
more likely to have flaws than those with better
welds with more comprehensive radiography would be detected at in
time.

5 Conclusions

This document presents and explains the potential assumptions
remediation strategies for the 488 improperly inspected welds, with a
preliminary sampling plan put together by the staff, two alternative

[4] Cochran, Sampling Techniques, 3rd ed., John Wiley and Sons. (1977) p. 5

sampling plans, and comprehensive risk-based approach. The potential advantages and disadvantages of [illegible] presented.

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

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

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