BEFORE THE MINNESOTA OFFICE OF ADMINISTRATIVE HEARINGS
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In the Matter of the Review of the July 2018–December 2019 Annual Automatic Adjustment Reports	MPUC Docket No. E-999/AA-20-171 OAH Docket No. 82-2500-37082

INITIAL BRIEF OF THE MINNESOTA DEPARTMENT OF COMMERCE, DIVISION OF ENERGY RESOURCES

June 28, 2021

TABLE OF CONTENTS

INTRODUCTION

Minnesota Power asks that the Public Utilities Commission permanently authorize forced outage costs that were provisionally charged to customers. Consistent with state law and Commission rules, Minnesota Power bears "the burden of proving that any or all of its forced outage costs were reasonably and prudently incurred, applying good utility practices."[1] Minnesota Power failed to prove that it prudently and reasonably incurred more than $6 million in forced-outage costs, because it failed to follow "good utility practice" in maintaining and repairing its coal fired power plant. Specifically, Minnesota Power has not demonstrated it followed good utility practice in inspecting and maintaining Boswell 4's hot reheat line. In addition, Minnesota Power has not demonstrated it followed good utility practice when it caused Boswell 3's phase bushings to fail by leaking oil into a generator component and not adequately cleaning it up. The Department of Commerce, therefore, recommends that Minnesota Power's customers receive a refund totaling $6,845,234 (assuming an October 2021 refund) for the forced outage costs related to these two outages.

FACTS

Between July 2018 and December 2019, Minnesota Power experienced 26 forced outage events.[2] A forced outage event occurs when an electrical generating unit is removed from service outside of a planned maintenance period or does not return to service as scheduled. During a forced outage, the utility will typically incur additional expenses from purchasing replacement

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[1] MP Ex. 1 at 4 (ORDER ACCEPTING 2018–2019 ELECTRIC AAA REPORTS; NOTICE OF AND ORDER FOR HEARING (Sept. 16, 2020) (eDocket No. 20209-166630-01)) ("Order"). *See also* Minn. Stat. § 216B.16, subd. 7(1) (2020); Minn. R. 7825.2920 (2019).

[2] Minn. Power's 2018-2019 Annual Automatic Adjustment of Charges Report, Attach. No. 15 at 7–9 (Mar. 2, 2020) (eDocket Nos. 20203-160872-01, 20203-160872-02) ("AAA Report").

power and other costs.[3] The Department objected to these forced outage costs, and the Commission ordered a contested case.[4]

All 26 forced outages occurred at Minnesota Power's Boswell Energy Center in Cohasset, Minnesota. Boswell is a coal-fired power plant. It had four different generation units. Boswell 1 and 2 were retired in 2018. Boswell 3 and Boswell 4 remain in service.[5] These remaining units meet about half of Minnesota Power's energy needs.[6]

GDS Associates, Inc., a firm with engineering expertise retained by the Department, determined that Minnesota Power failed to follow good utility practices, which led to forced outages from a hot reheat line rupture and a phase bushing failure.[7]

A. Hot Reheat Line Rupture

Boswell—like other thermal power plants—uses superheated, high-pressure steam to generate electricity. Moving water and steam from the boiler through the turbine requires a network of piping. In February 2019, a pipe section at Boswell 4 called the "hot reheat line" ruptured along a longitudinal seam-weld.[8] Longitudinal seam-welded pipe is formed by rolling plate steel into a pipe shape and welding the seam shut.[9] The two-foot long longitudinal seam-weld rupture allowed thousand-degree, high-pressure steam to erupt from a vertical section of the

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[3] DER Ex. 12 at 6–7 (Campbell Direct). Unless otherwise noted, citations are to public versions of exhibits.
[4] Order at 8.
[5] MP Ex. 6 at 2 (Poulter Direct).
[6] *Id.*
[7] DER Ex. 10 at 48–49 (Polich Direct).
[8] MP Ex. 7 at 15 (Undeland Direct).
[9] DER Ex. 10 at 21–22 (Polich Direct).

three-foot diameter, 1.5-inch thick steel pipe.[10] The rupture forced Minnesota Power to shut down Boswell 4 for seven weeks.[11]

In the aftermath, two different contractors and a utility industry organization investigated Minnesota Power's hot reheat pipe rupture. They concluded that ultrasonic examination would have likely identified the faulty pipe up to seven years prior to the rupture, that the hot reheat pipe's longitudinal seam-welds were beyond their predicted usable life, and that Minnesota Power's ten-year inspection schedule was inadequate.

Initially, Minnesota Power directed Thielsch Engineering to inspect the 640-foot hot reheat line. This was the ruptured pipe section's first inspection in nine years. The inspection revealed additional damaged or degraded pipe sections, including three 20-foot sections that had to be replaced entirely, and an additional three sections with significant cracking—totaling 140-feet in length—that required welding steel reinforcing patches along the longitudinal seam-welds.[12] Thielsch concluded that the hot reheat line's cracking started in the middle of the pipe wall along the seam weld approximately seven to nine years before the actual rupture. Thielsch also acknowledged that ultrasonic examination would likely reveal similar mid-wall cracking elsewhere in the pipe.[13]

After receiving Thielsch's analysis, Minnesota Power concluded that the hot reheat line failed due to a mechanism called "creep."[14] Boswell 4's hot-reheat-pipe creep damage was caused by slow developing voids and microcracks in the longitudinal seam-welds that ultimately result in

[10] *Id.* at 20, 22–23.
[11] MP Ex. 8, LOB-1 (Oehlerking-Boes Direct).
[12] MP Ex. 7 at 19–20, PJU-3 at 8 (Undeland Direct); DER Ex. 10 at 22–23 (Polich Direct).
[13] DER Ex. 10 at 31–32 (Polich Direct).
[14] *Id.*, RAP-12 at 10–11 (MP Power Point).

pipe failure.[15] These cracks begin in the pipe interior and eventually spread to the outside.[16] At some point, the pipe will fail as the cracks propagate from the inside of the pipe toward the pipe surface through a significant portion of the pipe wall and become long enough that the pipe's strength is compromised and cannot sustain the operating pressure.[17] Phased array ultrasonic examination can locate the voids and microcracks that occur deep within the longitudinal seam-welds of the 1.5-inch thick hot reheat pipe.[18]

In addition to Thielsch, Minnesota Power hired Structural Integrity Associates in March 2019 to evaluate the hot reheat line following the rupture.[19] Structural Integrity concluded that almost all the hot reheat line welds had exceeded their predicted usable life, and that it was difficult to understand why Minnesota Power had not previously identified the cracks.[20]

The Electric Power Research Institute ("EPRI") also investigated the rupture. EPRI's review concluded that Minnesota Power should have inspected the entire hot reheat line on a rotating, annual basis over a four to five-year period using ultrasonic examination.[21] Similarly, the American Society of Mechanical Engineers ("ASME") code recommends a maximum five-year inspection timeline for critical piping systems, including hot reheat lines, subject to corrosion or erosion.[22] Minnesota Power, however, used a ten-year, long-term high-energy piping inspection

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[15] *Id.* at 33. *See also* DER Ex. 19 at 3-22 to 3-23 (EPRI, *Fossil Plant High-Energy Piping Damage: Theory and Practice*).
[16] DER Ex. 10 at 33 (Polich Direct).
[17] *Id.*
[18] *Id.*; MP Ex. 14, PJU-1 at 31–32 (Undeland Rebuttal) (EPRI Guidelines).
[19] DER Ex. 10 at 30 (Polich Direct).
[20] *Id.*, RAP-11 at 56, 61.
[21] *Id.* at 38; *see* MP Ex. 14, PJU-1 at 413 (Undeland Rebuttal) (EPRI 30 Year Report); DER Ex. 10, RAP-13 at 13 (Polich Direct) (EPRI Power Point).
[22] DER Ex. 10 at 24 (Polich Direct).

plan when Boswell 4's hot reheat line failed. As part of this plan, Minnesota Power only conducted ultrasonic examination of longitudinal seam-welds every ten years.[23]

The post-failure inspections performed by Thielsch and Structural Integrity were not the hot reheat line's first evaluations. Thielsch also had inspected multiple hot reheat pipe sections in 2012, 2015, and 2017.[24] Yet, these inspections did not include longitudinal seam-weld inspection using ultrasonic examination techniques that would have identified interior cracking or deterioration in the longitudinal seam-welded pipe.[25] Thielsch, instead, relied on "in-situ metallographic examination" and "magnetic particle inspection" techniques.[26] Neither technique, however, can identify cracks or creep deterioration unless they are located near the outside pipe surface.[27] Consistent with EPRI's recommendation, the Department's expert testified that "in-situ metallographic examination" and "magnetic particle inspection" were inadequate. Instead, Minnesota Power's maintenance program should have inspected all longitudinal seam-welded pipe every five years using phased array ultrasonic examination.[28]

Many hot reheat line failures along seam welds have been catastrophic.[29] Since 1985, EPRI has documented more than 42 seam welded high energy pipe failures.[30] The most catastrophic hot reheat line rupture from a long-seam weld failure occurred at the Mohave Unit 2 coal fired plant in Nevada in 1985. The rupture released steam directly into several rooms where

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[23] MP Ex. 5 at 7–8 (Simmons Direct); DER Ex. 10 at 26 (Polich Direct).
[24] DER Ex. 10 at 26 (Polich Direct).
[25] *Id.* at 26–27.
[26] *Id.* at 26.
[27] *Id.* at 27–28.
[28] *Id.* at 28.
[29] *See* MP Ex. 14, PJU-1 at 408 (Undeland Rebuttal) (*30-Plus Years of Long-Seam Weld Failures in the Power Generation Industry* ("30 Year Report")).
[30] *Id.*, PJU-1 at 403.

staff congregated.[31] Six plant workers died and another ten were injured.[32] In addition, the plant experienced more than $155 million in damage excluding workers compensation, insurance adjustments, and liability and litigation.[33] Many other hot reheat line failures on seam welds have been recorded, including failures at power plants in Texas in 1979, Michigan in 1986, and West Virginia in 2014.[34]

B. Phase Bushing Failure

In March 2019, Minnesota Power attempted to find and fix Boswell 3's hydrogen gas leak. After other efforts failed, Minnesota Power eventually traced the problem to the hydrogen seal oil system. While searching for the hydrogen leak, Minnesota Power flooded the generator's seal oil system with oil.[35] This resulted in flooding the generator's float trap, which helped Minnesota Power find the leak's source. Minnesota Power, however, did not measure or track how much seal oil was used in the process.[36] Minnesota Power also did not investigate any seal oil leakage into the generator. The company also did not clean up or remove any leaked seal oil used to flood the seal oil system; in part, because it did not know how much had been used.[37] After fixing the hydrogen leak, Minnesota Power brought Boswell 3 back online on June 22.[38]

Just over two weeks later, on July 8, Boswell 3 experienced yet another outage. This time, the generator's "A" phase line-side bushing failed.[39] Bushings are cylindrical structures that

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[31] *See id.*, PJU-1 at 411–12.
[32] *Id.*, PJU-1 at 412.
[33] *Id.*, PJU-1 at 422.
[34] *See id.*, PJU-1 at 399–432.
[35] DER Ex. 10 at 43 (Polich Direct); DER Ex. 10, RAP-15 at 5 (Polich Direct) (MP IR Response).
[36] *Id.*, RAP-15 at 5.
[37] *Id.* at 44.
[38] MP Ex. 3, PJU-4 at 10 (Undeland Direct).
[39] MP Ex. 3 at 32 (Undeland Direct).

insulate a conductor from the surrounding steel generator housing while carrying electric current at high voltage. The outage lasted two weeks.[40]

Just three months before, in April 2019, General Electric had inspected and serviced Boswell 3's six bushings.[41] To investigate the failure, Minnesota Power again hired General Electric. General Electric found that: (a) the insulation around the bushing was soaked with oil, (b) the line side bushing was saturated with oil, (c) the neutral side bushing was contaminated with oil, and (d) the putty seal on the line side of the bushing was missing.[42] General Electric eventually found oil contamination in all six bushings after disassembling them. In total, five gallons of oil were pumped from each bushing.[43] Minnesota Power admitted that the oil found in the bushings was leftover seal oil that it used to locate the hydrogen leak.[44] Oil contamination can cause phase bushings to fail from overheating.[45]

C. Good Utility Practice

Minnesota Power bears "the burden of proving that any or all of its forced outage costs were reasonably and prudently incurred, applying good utility practices."[46] The Department and Minnesota Power agree that "good utility practice" means:

> [A]ny of the practices, methods, and acts engaged in or approved by a significant portion of the electric utility industry during the relevant time period, or any of the practices, methods, and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety, and expedition.[47]

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[40] *Id.*
[41] *Id.*
[42] DER Ex., RAP 16 at 4–5 (General Electric Report).
[43] DER Ex. 10 at 46–47 (Polich Direct).
[44] *See* DER Ex. 10, RAP-15 at 4 (Polich Direct) (MP IR Response).
[45] *Id.*, RAP-16 at 4 (General Electric Report).
[46] Order at 4.
[47] DER Ex. 10 at 7–8 (Polich Direct); MP Ex. 14 at 8 (Undeland Rebuttal).

The Department and Minnesota Power also agree that "good utility practice" is not intended to be limited to the optimum practice, methods, or acts generally accepted in the region in which the project is located.[48]

ARGUMENT

Minnesota Power failed to prove it applied good utility practice in its maintenance, inspection, and repair practices, which led to three outages: the hot reheat line rupture at Boswell 4; the hydrogen cooling system leak at Boswell 3; and the phase bushing failure at Boswell 3. Minnesota Power should not be authorized to retain permanently revenues received from customers for costs that were not reasonably incurred. Minnesota Power should instead be required to refund the forced outage costs for two of these outages—the hot reheat line failure and the phase bushing failure. For the hydrogen cooling system leak, Minnesota Power's failure to follow good utility practice did not contribute significantly to the length of the outage. The Department, therefore, does not recommend a refund of forced outage costs for the hydrogen cooling system leak. The Department and Minnesota Power agree on the amounts that should be refunded to customers if the Commission determines that Minnesota Power's failure to prove it followed good utility practices resulted in the outages.

I. MINNESOTA POWER FAILED TO SHOW THAT IT APPLIED GOOD UTILITY PRACTICE IN INSPECTING THE HOT REHEAT LINE.

Minnesota Power has the burden to prove that its forced outage costs were reasonably and prudently incurred, applying good utility practice.[49] There are two separate methods to determine "good utility practice": (1) whether the practices, methods, and acts were engaged in or approved

[48] DER Ex. 10 at 7–8 (Polich Direct); MP Ex. 14 at 8 (Undeland Rebuttal).
[49] Order at 5.

by a significant portion of the electric utility industry; or (2) whether the practices, methods, and acts, exercising reasonable judgment with the facts known at the time, would be expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety, and expedition.[50]

Under either standard, Minnesota Power failed to follow good utility practice in its inspection program of its hot reheat line. First, Minnesota Power's ten-year inspection schedule for the hot reheat line did not meet industry standards set by ASME and EPRI. For example, ASME recommends a five-year inspection schedule for hot reheat lines. Also, EPRI's guidelines for evaluating longitudinal seam-welded high-energy piping recommend using phased-array ultrasonic examination on longitudinal seam-welds every four to five years. Minnesota Power pointed to no industry standard, other than remarks from its own contractor, to support its ten-year inspection schedule. Second, the well-known potential for high human and economic costs from hot reheat line ruptures dictate that a ten-year schedule is simply too long, and Minnesota Power's claims that inspecting more frequently would be uneconomical are unsupported.

A. Minnesota Power's Ten-Year Inspection Schedule for the Hot Reheat Line Longitudinal Seam-Welds Was Not Good Utility Practice.

Minnesota Power's high-energy piping contractor, Thielsch, estimated that the creep cracks in the failed hot reheat line seam weld formed approximately 60,000 to 70,000 operating hours before the February 2019 rupture.[51] Assuming reasonable plant usage, the cracks likely would have been first detectable between early 2011 and late 2012—long before the hot reheat

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[50] DER Ex. 10 at 7–8 (Polich Direct). Minnesota Power did not dispute the Department's proposed definition of "good utility practice." MP Ex. 14 at 8 (Undeland Rebuttal).
[51] DER Ex. 10, RAP-6 at 7 (Polich Direct) (Feb. 20, 2019 Thielsch Report).

line failure.[52] Another Minnesota Power contractor, Structural Integrity, was puzzled that these flaws were not detected earlier.[53]

Minnesota Power's over-reliance on magnetic particle inspection and in-situ metallographic examination was inconsistent with good utility practice since these inspection methods only detect surface flaws. The creep damage that occurred in the 1.5-inch thick hot reheat line's longitudinal seam-welds initially occurred deep inside the pipe wall below the pipe surface. And, Minnesota Power's ten-year schedule for ultrasonic examination of Boswell 4's hot reheat line longitudinal seam-welded pipe was simply too long. Both ASME and EPRI recommend inspecting longitudinal seam-welded pipe in hot reheat lines on a five-year schedule. And EPRI specifically recommends inspecting longitudinal seam-welds with ultrasonic examination.[54] Minnesota Power pointed to no other general industry standard to support its ten-year inspection schedule. Instead, Minnesota Power contended without basis that the purported practices of other Thielsch customers equates to good utility practice. This is unpersuasive.

1. Relying on non-ultrasonic examination methods to inspect longitudinal seam-welds is not good utility practice.

Creep cracks, the predominate failure mechanism for longitudinal seam-welded pipe, evade detection through magnetic particle inspection and in-situ metallographic examination because they often start as small voids or microcracks located deep within the pipe wall.[55] But phased array ultrasonic examination can locate creep damage of this type before the pipe risks

[52] *See* DER Ex. 10 at 32 (Polich Direct). Mr. Polich calculated a 7.5 to 8.9 year estimate, assuming operation at 90 percent of the 8,760 hours in a year. *Id.*
[53] *See* DER Ex. 10, RAP-11 at 61 (Polich Direct) (Structural Integrity Report).
[54] MP Ex. 14, PJU-1 at 183, 185 (Undeland Rebuttal) (EPRI Guidelines)
[55] DER Ex. 10 at 27–28 (Polich Direct).

failure.[56] Yet, the hot reheat line's long-run straight portions, including the ruptured pipe section, were last inspected using ultrasonic examination in 2010.[57]

The Department's expert testified that Minnesota Power's high-energy piping inspection program should have inspected the entire longitudinal seam-welded pipe every five years using phased-array ultrasonic examination.[58] If structured correctly—by inspecting different pipe sections on a rotating, annual basis—the longitudinal seam-weld flaws likely would have been discovered.[59] Identifying such flaws would then trigger a more detailed examination, through scoop or boat sampling, to catch the creep formations before the pipe failed.[60] This five-year schedule and process is supported by both the ASME Code recommendations and EPRI's *Guidelines for Evaluation of Seam-Welded High-Energy Piping-* ("EPRI Guidelines"), as discussed further below.

2. The ASME Code recommends a five-year inspection schedule.

Minnesota Power's ten-year inspection schedule is inconsistent with ASME's hot reheat line recommendations.[61] The ASME Code recommends examining hot reheat lines at intervals

[56] *Id.* at 27–28; MP Ex. 14, PJU-1 at 31 (Undeland Rebuttal) (EPRI Guidelines).
[57] DER Ex. 10 at 26 (Polich Direct).
[58] *Id.* at 28.
[59] *Id.*
[60] *See id.* at 28–29.
[61] While ASME Code B31.1 prescribes mandatory minimum requirements for the construction of power piping, statements in the appendices regarding operating and maintenance are recommendations. *See* MP Ex. 22a at 321 (ASME Code B31.1, Appendix V). The recommendations are important, however, because "the design of a piping system assumes that reasonable maintenance and plant service will be provided" and "lack of this support will, in some cases, introduce an increasing degree of piping system life uncertainty." *Id.*

not exceeding five years.[62] Minnesota Power disagreed that the ASME Code recommendation applied to its hot reheat line.[63]

Section 8 of Appendix V of the ASME code provides the recommendations at issue. Section 8.1 describes the types of power piping subject to ASME's five-year maximum inspection recommendation, which includes critical piping systems subject to internal or external corrosion-erosion:

> This section pertains to the requirements for inspection of critical piping systems that may be subject to internal or external corrosion-erosion, such as buried pipe, piping in a corrosive atmosphere, or piping having corrosive or erosive contents. Requirements for inspection of piping systems to detect wall thinning of piping and piping components due to erosion/corrosion, or flow-assisted corrosion, are also included. Erosion/corrosion of carbon steel piping may occur at locations where high fluid velocity exists adjacent to the metal surface, either due to high velocity or the presence of some flow discontinuity (elbow, reducer, expander, tee, control valve, etc.) causing high levels of local turbulence. The erosion/corrosion process may be associated with wet steam or high purity, low oxygen content water systems. Damage may occur under both single and two phase flow conditions. Piping systems that may be damaged by erosion/corrosion include, but are not limited to, feedwater, condensate, heater drains, and wet steam extraction lines. Maintenance of corrosion control equipment and devices is also part of this section. Measures in addition to those listed herein may be required.[64]

Hot reheat lines are covered by section 8 because they are subject to erosion/corrosion.[65] As stated in the code, "Erosion/corrosion of carbon steel piping may occur at locations where high-fluid

[62] DER Ex. 10 at 24 (Polich Direct) (discussing ASME Code Section 8 located at MP Ex. 22a at 325, 329 (ASME Code B31.1, Appendix V)).
[63] MP Ex. 14 at 19–22 (Undeland Rebuttal).
[64] MP Ex. 14 at 20 (Undeland Rebuttal). A public version of the relevant section of the ASME code is contained in Mr. Undeland's rebuttal testimony. The code itself is proprietary and designated as Trade Secret. The full version of ASME Code B31.1 is included in the record as MP Ex. 22a.
[65] Evid. Hrg. Tr. at 78 (Polich).

velocity exists adjacent to the metal surface."[66] The Department's engineering expert explained that high-energy steam piping systems will develop "certain innate oxide layers on the surface of the piping"—"rust" in lay terms.[67] High-velocity fluids strip rust away exposing bare pipe causing erosion of the piping, which weakens the pipe over time.[68]

Minnesota Power agreed that its hot reheat line is a critical piping system.[69] But the company disagreed that section 8 applies, arguing that the pipe did not fit any of the examples of piping systems provided.[70] But the code clearly does not limit the types of pipes it covers to the provided examples, and instead uses the terms "such as" and "include, but are not limited to."[71]

Minnesota Power should have followed the ASME recommendations and inspected the hot reheat line on a five-year schedule. A ten-year schedule was not good utility practice and significantly contributed to the failure to detect the flaw in the hot reheat line before it failed.

3. EPRI's Guidelines recommend a five-year inspection schedule.

EPRI recommends inspecting all longitudinal seam-welds on high energy piping systems with phased-array ultrasonic examination every four to five years.[72] EPRI has studied seam-welded high energy piping failures for many years and, based on its investigation, published the

[66] MP Ex. 14 at 20 (Undeland Rebuttal).
[67] Evid. Hrg. Tr. at 78–79 (Polich)
[68] *Id.* at 79.
[69] Evid. Hrg. Tr. at 31 (Undeland).
[70] MP Ex. 14 at 21 (Undeland Rebuttal).
[71] *Id.* at 20. Minnesota Power also appears to dispute that the hot reheat line is subject to "high fluid velocity," but it did not provide the velocity of superheated steam in the hot reheat pipe in the record. Evid. Hrg. Tr. at 31–32 (Undeland).
[72] *Id.* Mr. Polich explained that while the 2003 EPRI guidelines do not give a succinct recommendation of 100 percent five-year inspection using ultrasonic phased array examination, other EPRI documents so state and reference the EPRI Guidelines. Evid. Hrg. Tr. at 66–67 (Polich). These other EPRI documents include EPRI's 30 Year Report and the presentation that EPRI gave to Minnesota Power following the hot reheat line failure. *See* MP Ex. 14, PJU-1 at 413 (Undeland Rebuttal) (EPRI 30 Year Report); DER Ex. 10, RAP-13 at 13 (Polich Direct) (EPRI Power Point).

EPRI Guidelines.[73] Based upon crack propagation rates in EPRI case studies, EPRI found that flaws leading to longitudinal seam-welded high energy piping failures can be reliably detected with phased-array ultrasonic examination, if performed four to five years before the pipe failure.[74]

EPRI has also periodically conducted surveys of whether utilities are following the EPRI Guidelines and concluded that almost 50% of respondents followed the guidelines related to ultrasonic flaw detection.[75] Minnesota Power disputed that 50% of the responding utilities to EPRI's survey complied with the EPRI Guidelines. To reach this conclusion, Minnesota Power misrepresented EPRI's findings and emphasized that only 2% of utilities were "following all of EPRI's suggested procedures."[76] While EPRI states that only 2% of utilities "complied *completely* with the EPRI Guidelines," it states that 41% complied for the most part.[77] More importantly, ERPI states, "Almost 50% of respondents followed the EPRI Guidelines related to ultrasonic flaw 'detection,' but deviated from the Guidelines only with respect to crack 'sizing.'"[78] That is, unlike Minnesota Power, almost 50% of survey respondents performed ultrasonic testing on longitudinal seam-welds to try to detect flaws, although these utilities may have differed on the specific methodology used to determine the flaws' size. As EPRI emphasizes, "flaw detection is the highest priority in any inspection."[79] EPRI's survey shows that a significant portion of the utility industry substantially complies with the EPRI Guidelines to detect flaws in longitudinal seam-welds using ultrasonic testing.

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[73] DER Ex. 10 at 22 (Polich Direct). *See generally* MP Ex. 14, PJU-1 at (Undeland Rebuttal) (EPRI Guidelines).
[74] *Id.* at 25.
[75] MP Ex. 14, PJU-1 at 3, 33 (Undeland Rebuttal) (EPRI Guidelines).
[76] MP Ex. 14 at 24 (Undeland Rebuttal).
[77] MP Ex. 14, PJU-1 at 33 (Undeland Rebuttal) (EPRI Guidelines) (emphasis added).
[78] *Id.*
[79] *Id.*

Unlike almost 50% of responding utilities, Minnesota Power conducted no ultrasonic testing of the longitudinal seam-welds on its hot reheat line in the nine years before the pipe ruptured. The EPRI Guidelines support that good utility practice requires inspection of these highly unstable longitudinal seam-welds, which are highly susceptible to creep deterioration, more often than every ten years.

4. Minnesota Power's claims that it followed good utility practice based on hearsay from its contractor are not persuasive.

Minnesota Power argued that its ten-year inspection schedule was consistent with good utility practice, because its high-energy piping contractor, Thielsch, told someone at Minnesota Power that its other coal plant customers use a ten-year inspection schedule.[80] Minnesota Power deemed this statement, the "Thielsch's survey."[81] This purported statement from Thielsch are unavailing. First, the statement is unreliable hearsay. No one from Thielsch testified. Minnesota Power did not document this claim from Thielsch.[82] And, the individual(s) at Minnesota Power to whom this statement was made are likewise unidentified. Second, Thielsch is hired by utilities, like Minnesota Power, to help develop high-energy piping inspection programs. Presumably, Thielsch gives consistent advice on inspection timelines to its customers.[83] The results of the purported "Thielsch survey," therefore, reflect a bias toward a ten-year inspection program. This undocumented and self-serving claim provides little support regarding whether Minnesota Power's program is consistent with good utility practice.

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[80] MP Ex. 3 at 18–19 (Undeland Direct).
[81] MP Ex. 14 at 25 (Undeland Rebuttal).
[82] *See* Evid. Hrg. Tr. at 24–25 (Undeland). Although the Department did not object to the introduction of Mr. Undeland's statements to this effect as inadmissible under OAH's rules of evidence, the Department submits that it is not the type of evidence that reasonable persons would rely on and should be given limited weight. *See* Minn. R. 1400.7300, subd. 1 (2019).
[83] *See* Evid. Hrg. Tr. at 28–29 (Undeland) (acknowledging that Thielsch likely gives consistent advice to its customers).

B. A Hot Reheat Line Failure's High Costs Dictate that Good Utility Practice Requires Inspecting 100% of an Aging Line More than Every Ten Years.

Minnesota Power's ten-year inspection schedule is inconsistent with good utility practice considering the high potential human and economic costs of hot reheat line failures. "Good utility practice" includes practices "which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety, and expedition."[84]

Unabated creep cracking caused the hot reheat line rupture. This is hardly a surprise. EPRI has documented numerous longitudinal seam-welded pipe failures with the same creep deterioration as occurred in Boswell 4's hot reheat line over the past 30 years.[85] In fact, EPRI has documented more than 42 seam-welded pipe failures since 1985.[86] Minnesota Power knew these types of failures were an industry wide problem that could result in high-costs for replacement power and repairs, injuries, or even deaths.[87] Exercising reasonable judgment in light of these serious and well-known consequences, as good utility practice requires, dictates that more frequent inspections of the entire hot reheat line were warranted. Moreover, Minnesota Power has not supported its claims that inspecting the line more often would be cost prohibitive. Minnesota Power has, therefore, failed to carry its burden to show that its ten-year inspection schedule was in-line with good utility practice.

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[84] DER Ex. 10 at 7–8 (Polich Direct).
[85] DER Ex. 10 at 32 (Polich Direct); MP Ex. 14, PJU-1 at 399–432 (Undeland Rebuttal) (EPRI 30 Year Report).
[86] MP Ex. 14, PJU-1 at 403 (Undeland Rebuttal) (EPRI 30 Year Report).
[87] MP Ex. 6 at 12 (Poulter Direct); Evid. Hrg. Tr. at 36-39 (Undeland).

1. Other hot reheat line failures have caused catastrophic damage, injuries, and deaths.

Like EPRI, Minnesota Power knew that hot reheat line failures were an industry-wide problem before Boswell 4's line rupture. One company witness admitted that "[hot reheat] piping has been an on-going power generation industry topic for over 30 years."[88] That witness further explained, "Starting in the late 1970s the utility industry experienced failures in seam welded pipe."[89] Many hot reheat line failures along longitudinal seam-welds have been catastrophic, causing damage to power plants, high-replacement power costs, injuries, and fatalities.[90]

In the face of this known history of catastrophic hot-reheat-pipe ruptures, Minnesota Power focused its inspection efforts on what it terms the "high-stress areas," which it describes as those areas "where there are attachments such as pipe hangers or laterals."[91] Failing to give attention to the longitudinal seam-welds (what Minnesota Power terms "low-stress areas") is unfounded and unwise, given that almost all of the largest outages in both main steam and hot reheat piping systems have been on longitudinal seam-welds.[92] While seam-weld failures may be less common, the grave consequences of these failures favor more frequent inspections than once every ten years.[93]

2. Minnesota Power's claim that inspection would be cost prohibitive is unsupported.

Despite the known high potential costs of high energy piping ruptures, Minnesota Power asserts that ultrasonic examination of the hot reheat line on a five-year cycle would be cost-

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[88] MP Ex. 6 at 12 (Poulter Direct).
[89] *Id.* at 13.
[90] *See* MP Ex. 14, PJU-1 at 399–432 (Undeland Rebuttal) (EPRI 30 Year Report).
[91] MP Ex. 6 at 13 (Poulter Direct).
[92] DER Ex. 21 at 4 (MP IR Attach 05.05: Cohn et al, *A Quantitative Approach to a Risk-Based Inspection Methodology of Main Steam and Hot Reheat Piping Systems*).
[93] *Id.* at 5.

prohibitive. The company claims it would cost more than $5 million to inspect the whole line every five years. For this proposition, Minnesota Power relies on a single sentence in an EPRI whitepaper stating that the EPRI guideline "regarding a five-year inspection interval is viewed as cost-prohibitive with the estimate cost for a single HRH piping system to be on the order of $5 million."[94]

Yet, Thielsch offered to perform an ultrasonic examination of a vertical section Minnesota Power's hot reheat line for $35,000 in 2013.[95] Minnesota Power disputes that cost estimate, stating that it "did not include the costs of scaffolding, removing insulation, surface preparation, reinsulating, removing the scaffolding, and potentially extending an outage to complete the full inspection."[96] Minnesota Power, however, did not provide any estimates of how much these additional costs would add or how much ultrasonic examination would cost.[97] How Minnesota Power gets from the $35,000 estimate that Thielsch provided in 2013 to claiming a cost over 140 times that remains a mystery.[98]

The company alternatively suggested that ultrasonic examination costs should be weighed against the risk of a hot reheat line failure. While the Department agrees that this cost balancing may be useful to establish good utility practice, Minnesota Power's analysis fails on both its assessment of inspection costs, discussed above, and its assessment of the costs of a failed hot reheat line. In its analysis, Minnesota Power considered the material, labor, and replacement

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[94] MP Ex. 14, PJU-1 at 427 (Undeland Rebuttal) (EPRI 30 Year Report).
[95] DER Ex. 10 at 15, RAP-3 (Polich Direct).
[96] MP Ex. 14 at 28 (Undeland Rebuttal).
[97] Evid. Hrg. Tr. at 32–35 (Undeland); MP Ex. 14 at 29 (Undeland Rebuttal).
[98] Mr. Undeland indicated at the "industry standard" for inspection costs would be "anywhere from five to ten times higher than the cost of simply performing the inspection." Evid. Hrg. Tr. at 33 (Undeland). Therefore, assuming Mr. Undeland's ad hoc cost estimate is accurate, the highest end estimate for the hot reheat line inspection would be approximately $350,000, not $5 million.

power costs relating to a hot reheat line failure.[99] A catastrophic failure, however, can present other costs, such as costs from damage to other portions of the plant, worker injuries, and the immeasurable cost of the loss of human life.[100] Minnesota Power ultimately admitted that other plants have experienced these costs from hot reheat line failures.[101]

Lastly, Minnesota Power has the burden of proving it followed good utility practice. Minnesota Power failed to estimate the costs of complying with a five-year inspection program to detect creep in seam-welded pipes. Instead, the company assumed the expense outweighed any possible benefit.[102] Minnesota Power's witness testified "Minnesota Power has not specifically estimated the cost associated with such an inspection protocol because it would be significantly higher than the potential benefits."[103] Assumptions are not substitutions for evidence. Minnesota Power's ad hoc and unpersuasive estimates based on industry-wide views and off-the-cuff remarks should carry little weight. Moreover, Minnesota Power's generalized balancing of inspection costs versus forced-outage costs failed to account for the worker safety benefits associated with ultrasonic examination.

Minnesota Power failed to show its high-energy piping inspection program met good utility practice. Its program was inconsistent with good business practices, reliability, and safety, and not outweighed by unreasonable costs.

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[99] MP Ex. 5 at 27 (Simmons Direct).
[100] *See* MP Ex. 14, PJU-1 at 399–423 (Undeland Rebuttal).
[101] Evid. Hrg. Tr. at 36–39 (Undeland).
[102] MP Ex. 14 at 29 (Undeland Rebuttal).
[103] *Id.*

II. MINNESOTA POWER'S FAILURE TO FOLLOW GOOD UTILITY PRACTICE IN ADDRESSING THE HYDROGEN LEAK CAUSED THE PHASE BUSHING OUTAGE.

Minnesota Power's phase bushing outage was inconsistent with good utility practice. While Minnesota Power appears to have inspected the bushings appropriately, its failure to account for and clean up the seal oil it leaked into Boswell 3's generator while resolving the hydrogen leak contributed to the bushing outage just 16 days after the unit came back online. The Department's witness expert concluded that Minnesota Power's seal oil contamination caused the bushings to fail. This opinion is supported by General Electric's own concern about the oil's potential to overheat the bushings. Lastly, Minnesota Power's alternative causation theories are unpersuasive considering the recent bushing inspection—just three months prior to the phase bushing failure. In sum, Minnesota Power has not carried its burden to show that it followed good utility practices related to the phase bushing outage.

A. Minnesota Power Did Not Follow Good Utility Practice When an Unknown Amount of Seal Oil Leaked into the Generator and It Did Not Investigate.

Minnesota Power failed to follow good utility practice in at least three ways related to how it located the hydrogen leak: (1) it failed to monitor the amount of seal oil it used when determining the source and cause of the hydrogen leak in the seal oil system; (2) it failed to record the amount of seal oil that was drained out of the seal oil system once the leak was located; and (3) it failed to inspect the generator to determine if any seal contamination occurred.[104] As the Department's expert testified, "Good utility practice would be to keep track of the amount of seal oil used in any

[104] DER Ex. 10, RAP-15 at 2, 5 (Polich Direct) (MP IR Response).

testing process, track any leakage, and clean up any leaked seal oil so it does not cause damage to other components of the generator."[105]

If Minnesota Power had monitored the amount of seal oil it had introduced and compared it to the amount it drained, it likely would have discovered at least 30 gallons of unaccounted for seal oil.[106] Even though Minnesota Power failed to track the specific amount of seal oil, it should have inspected the generator thoroughly to ensure that seal oil had not contaminated generator components. If it had, Minnesota Power would likely have noticed the oil-soaked bushing insulation and oil in the generator phased bushings.

Minnesota Power's failed to follow good utility practice. Its actions also defy common sense. For example, if a car was a quart low on oil and the owner added six quarts only to have the dip stick show it was still a quart low, a reasonable and prudent person would investigate where the additional oil went or risk an engine fire. Minnesota Power should, likewise, have used common sense to track how much additional seal oil it introduced into the system and made sure the excess seal oil came out. Likewise, it is common sense that if you make a mess, for instance by flooding a system with excess oil, you should make sure it is cleaned up before restarting.

B. Minnesota Power Has Not Overcome the Commonsense Conclusion that the Seal Oil Left in the Generator Caused the Phase Bushings to Fail.

Minnesota Power admits that the large amount of oil contaminating the bushings was seal oil it introduced into the generator while trying to locate the hydrogen leaks.[107] Minnesota Power

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[105] DER Ex. 10 at 44 (Polich Direct).

[106] General Electric removed five gallons of oil from each of the six bushings and noted that the bushing insulation was soaked in oil. DER Ex. 10, RAP-16 at 4–5 (Polich Direct) (General Electric Report). Minnesota Power stated that "several barrels of oil were required to perform the testing, although the specific number was not recorded," but otherwise did not quantify the amount. DER Ex. 10, RAP-15 at 5 (Polich Direct) (MP IR Response).

[107] DER Ex. 10, RAP-15 at 4 (Polich Direct) (MP IR Response).

also does not appear to significantly dispute that failing to monitor the amount of oil introduced and removed, and failing to inspect the generator system for seal oil before restarting Boswell 3 was inconsistent with good utility practice. Instead, Minnesota Power engages in burden shifting by arguing that the Department has not proved that the large amount of excess seal oil in the phase bushings was the but for cause of the phase bushing failure. Yet, the conclusion that seal oil contamination caused the phase bushing failure is consistent with General Electric's report and supported by the Department's expert engineer following a review of Minnesota Power's records. Minnesota Power's alternative theories of causation are also inconsistent with the recent inspection of the bushings just three months earlier and the fact that the bushings failed just 16 days after bringing the generator back online after leaking significant amounts of seal oil into the generator.

1. Excess seal oil caused the phase bushing to overheat.

Both General Electric's report and the Department's expert conclusion show that the phase bushings overheated because they were full of seal oil left over from locating the hydrogen leak.

General Electric produced a report following its investigation of the phase bushing outage.[108] The report is replete with references to the large amount of seal oil that General Electric found in the insulation to the phase bushings and the bushings themselves.[109] General Electric observed in its report, "All of the bushings on this unit were full of oil," and that "[o]il will block the cooling passage through these bushings and can cause the bushings to overheat."[110] General Electric observed that the insulation on the bushing that grounded "was soaked with oil completely through the thickness of the layers of insulation" and another bushing's insulation also contained

[108] DER Ex. 10, RAP-16 at 3 (Polich Direct) (General Electric Report).
[109] *See id.*
[110] *Id.*, RAP-16 at 5.

oil "but was not as saturated" as the bushing that grounded.[111] General Electric pumped an estimated five gallons of oil out of each of the bushings.[112] General Electric found that no definitive physical damage could be seen on the failed bushing.[113] Although the report discusses a few other oddities such as tar on the flange of a bushing and higher than expected DC microamp leakage on one of the non-grounded bushings, the focus of the report is on the amount of oil in the bushings. Lastly, General Electric stated that Minnesota Power decided to replace all six bushings in part because "all 6 of the in-service bushings had been filled with oil."[114]

Likewise, following GDS Associates' investigation, the Department's expert concluded that in addressing the hydrogen leak, Minnesota Power should have followed good utility practices by investigating whether seal oil used to flood the seal oil system leaked into the generator, and if leakage was found, Minnesota Power should have cleaned up the leaked seal oil.[115] Taking these common sense steps "would have prevented the phase bushings from being filled with seal oil or would have found the seal oil in the bushing prior to startup, allowing the bushings to be cleaned."[116] The Department's expert further testified that this would have avoided the bushing failure, the need to purchase replacement bushings, and the roughly two-week outage.[117]

The Department expert based his conclusion on his review of Minnesota Power's investigation into the outage, more than 40 years of utility industry experience, and his work on scores of coal, gas, and nuclear plants.[118] This conclusion also is consistent with a plain reading

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[111] *Id.*, RAP-16 at 4.
[112] *Id.*, RAP-16 at 5.
[113] *Id.*, RAP-16 at 4.
[114] *Id.*, RAP-16 at 12.
[115] DER Ex. 10 at 44–45, 48 (Polich Direct).
[116] *Id.* at 48.
[117] *Id.*
[118] *Id.* at 1–5; Evid. Hrg. Tr. at 51–52 (Polich).

of General Electric's report, the fact that the bushings had been inspected just three months before, and the commonsense conclusion that the failure just 16 days after restarting the plant with substantial seal oil contamination could lead to problems.

2. Minnesota Power's alternative causation theories are unpersuasive.

Minnesota Power suggested several alternative theories for the phase bushing failure. But none of these alternative causation theories are persuasive given the recent inspection of the bushings in April and the timing of the outage. The much more likely explanation is that at least 30 gallons of excess oil in the system caused the phase bushings to overheat just 16 days after the plant was brought back online.

Minnesota Power suggested that sudden load changes, excessive vibration, overheating, and normal vibration over long periods of time could cause a bushing failure.[119] Minnesota Power also indicated that the bushings may have failed due to age because the bushings could have either been installed in 1970 or 2001.[120] Minnesota Power rests heavily on the fact that General Electric told Minnesota Power that it "was unable to conclude whether the presence of seal oil did or did not contribute to the failure."[121] But Minnesota Power did not provide persuasive evidence—as required by its burden in this case—that any other causes were more likely than overheating resulting from seal oil soaked bushings.

Minnesota Power agreed that General Electric did not point to any of these alternatives as the outage cause.[122] While Minnesota Power pushed a theory that tar found on the mounting flange could indicate excessive vibrations or long vibrations over time that could have contributed to the bushing failure, Minnesota Power did not recall General Electric mentioning concerns about this

[119] MP Ex. 14 at 35 (Undeland Rebuttal).
[120] MP Ex. 7 at 35 (Undeland Direct).
[121] MP Ex. 14 at 35 (Undeland Rebuttal).
[122] Evid. Hrg. Tr. at 40–43 (Undeland).

tar during its inspection just three months earlier.[123] Minnesota Power also did not introduce any evidence of actual sudden load changes leading up to the phase bushing failure.

Regarding Minnesota Power's indication that the bushing failed due to age, Minnesota Power does not even know how old the bushings were and instead stated they were anywhere from 18 to 49 years old. The bushings could have been installed as recently as 2001.[124] Minnesota Power's failure to keep accurate records of the age of its plant components should not be rewarded by adopting an unsupported assumption the bushing was old and failed. Even if the failed bushing was 49 years old, to accept Minnesota Power's theory, one must assume that in the 49 years of the bushing's operation, it happened to fail 16 days after being restarted with five gallons of oil in it.

Lastly, Minnesota Power ultimately acknowledged that General Electric stated that the bushings could have failed from overheating due to the oil blocking proper cooling.[125] The Commission should accept this commonsense conclusion supported by the Department's expert that the oil-soaked bushings overheated and failed. Minnesota Power failed to prove it followed good utility practice by failing to monitor and inspect the amount of oil in its system, and it should be required to refund the forced outage costs resulting from this failure to its customers.

III. FINANCIAL ADJUSTMENTS

Minnesota Power should refund forced outage costs arising from the hot reheat line rupture and the phase bushing failure to its customers. The Commission's Order provides that forced outage costs that were not reasonably and prudently incurred, applying good utility practice should be returned to customers.[126] State law and the Commission's rules further make clear that utilities are not guaranteed recovery of expenses, such as forced outages costs, that are automatically

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[123] *Id.* at 39–40.
[124] *See* MP Ex. 7 at 35 (Undeland Direct).
[125] Evid. Hrg. Tr. at 43.
[126] Order at 8.

passed through to customers through a rate rider. Instead, these costs are provisionally charged to customers subject to Commission review and possible refund.[127] Here, Minnesota Power failed to meet its burden of proving that it applied good utility practice in maintaining its hot reheat line and phase bushing facilities. Because Minnesota Power's failed to prove it observed good utility practice, its associated incremental forced outage costs could not have been reasonably and prudently incurred.[128] As a result, these costs should be refunded along with interest to customers, as required by the Commission's Order.

Minnesota Power and the Department agree that the incremental forced outage costs arising from the hot reheat line rupture and phase bushing failure equal $6,247,151.[129] They also agree Minnesota Power should apply the U.S. Federal Reserve prime rates that were applicable during the refund period to calculate the required interest.[130] This results in a refund of $6,845,234, assuming an October 2021 refund month.[131] In the event that the refund is not made in October 2021, interest would need to be adjusted to reflect the actual refund month.

Finally, Minnesota Power proposes a reasonable method for implementing this refund. The company states it would calculate specific refund amounts for the eight large power customers and seventeen municipal customers based on their actual kilowatt hour usage to which forced outage costs were applied. For its other customers, Minnesota Power would calculate the refund by taking the remaining refund amount divided by the forecasted sales for the applicable remaining customer

[127] Minn. Stat. § 216B.16, subd. 7(1) (2020) (authorizing rider cost recovery); Minn. R. 7825.2920 (2019) (provisionally approving rider costs subject to further review).
[128] Good utility practice is necessary, but not sufficient for a finding that incremental forced costs were reasonably and prudently incurred. If the utility, for example, failed to procure the least cost alternative energy following an outage event, then cost recovery might still be unreasonable or imprudent. This hypothetical, however, is not at issue in this proceeding.
[129] DER Ex. 12 at 17 (Campbell Direct); MP Ex. 17 at 2 (Oehlerking-Boes Rebuttal).
[130] DER Ex. 12 at 19–20 (Campbell Direct); MP Ex. 17 at 3 (Oehlerking-Boes Rebuttal).
[131] MP Ex. 17 at 3 (Oehlerking-Boes Rebuttal).

classes. This rate would be applied to actual usage in the refund month.[132] The Department agrees that this methodology produces reasonable results and supports it.

CONCLUSION

Minnesota Power failed to demonstrate it followed good utility practices in inspecting and maintaining its hot reheat line and its phase bushings. Minnesota Power's forced outage costs related to these failures, therefore, were not reasonably and prudently incurred. As a result, Minnesota Power should be required to refund $6,845,234 (assuming an October 2021 refund) to its customers.

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Respectfully submitted,

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[132] *Id.* at 3–4.