

## An AMAG Analogy Attachment 1

Bill and Ted live in the same neighborhood, are engineers for Exelon and work at the same location. They drive similar cars and are both very particular about maintaining their vehicles in pristine condition, following every aspect of maintenance, and always operating within the legal operating limits. Upon reading their owners manuals, they both noted that their speedometers have an accuracy of +/- 5 mph. Since the speed limit is 65 mph on their way to work, they always maintain their speedometers at  $\leq 60$  mph in order to ensure that they never exceed the speed limit.

One day Bill reads an advertisement in Popular Mechanics about a device that he could install in his fuel line that could more accurately measure fuel consumption rate, which could then be fed into an onboard computer system and provide an indication of vehicle speed to an accuracy of +/- 1 mph. Therefore, he would be able to drive his car at 64 mph without worrying about exceeding the speed limit. He shares this information with Ted and they both do the calculations and determine that they could save approximately 38.64 minutes of driving time each week by using this new technology. So, they install the new systems.

Bill and Ted are both very pleased with their improved performance and the benefits they derive from being more efficient. However, after a few weeks, Bill notices that although Ted leaves slightly later than him, Ted almost always passes him on the way to work and on the way home again. Bill mentions this to Ted, but Ted insists that he always keeps his speedometer at or slightly below 64 mph, just like Bill is doing. Of course, Bill has a gut feeling that something isn't quite right, but he decides to let it slide.

One day, on the way to work, Bill grudgingly waves to Ted as Ted slowly creeps past him again. However, a few miles down the road, Bill passes by Ted's car as it sits on the side of the road with a policeman writing Ted a speeding ticket. Later, Ted tells Bill that the policeman said that he clocked him doing 67 mph even though Ted is certain that his indications never exceed 64 mph. This event leaves the engineers to review their actions and re-evaluate the modifications they have made to their vehicles.

The case study we will be reviewing today, although somewhat more complex and ultimately of greater consequences to our entire industry, bears a few similarities to the Bill and Ted story.

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### AMAG Event Timeline Attachment 2

1998

- Exelon contracted with the Advanced Measurement and Analysis Group (AMAG), Inc. and Westinghouse to install improved feedwater flow measurement systems at several of our nuclear plants. The AMAG systems are designed to provide more accurate measurement of feedwater flows, thereby enabling the stations to slightly increase the electrical output of the units. Although the megawatt increase might appear small, the increase in revenue could amount to millions of dollars when taken in aggregate and over the course of a year.

1999

- Corporate engineering assigned a lead to the project who did not have an I&C background (forcing the lead to rely heavily on AMAG representatives for any technical issues).
- Of the four sites implementing AMAG, only LaSalle assigned a site project lead.
- AMAG offered a week of training for Exelon maintenance, operations and engineering personnel prior to installing the systems, but no one from the sites attended. This training had been funded by the original contract, but the money was subsequently diverted to the purchase of additional equipment. Some abbreviated training was provided one year later.
- AMAG was installed in April at Braidwood and in May at Byron with less post modification testing than what AMAG normally performs. AMAG testing results indicated that both stations could raise megawatt output, and that Byron units could gain 12 megawatts more per unit than the Braidwood units. This unexpected result was not documented with a CR.
- Braidwood and corporate engineers reviewed the AMAG results and various secondary plant parameters and determined that there was a good correlation between the readings. Since the results were consistent with their expectations prior to the AMAG implementation, in June Braidwood increased power by approximately 11 MW per unit. Byron did not implement AMAG at this time due to concerns over the divergence in test results between the stations.
- Corporate engineering requested that Stone and Webster review plant performance data for Byron and Braidwood in an effort to substantiate or refute AMAG results. Their report states, "... an increase in reactor power based on ultrasonic flow measurements (*AMAG*) seems imprudent without better data related to plant performance." No CR was written to address this concern.
- June - Corporate engineering requested that the Dresden Thermal Performance Engineer (TPE) evaluate the unexpected differences between Byron and Braidwood. This report concluded that, "...until we have resolved the cause for the discrepancy between the units, I recommend that Byron not change their FW flow by more than Braidwood has. This would...not give outside regulators any reason to question the results until we have a definitive answer." The engineer also recommended that a precision ASME secondary plant thermal performance examination be conducted. This information was not captured with a CR and the testing was not performed.
- July - The Byron TPE documented his position regarding AMAG in a memo to the Byron Engineering Director. He stated, "I do not support using AMAG." This was not documented with a CR.
- Byron did not implement AMAG and did no substantial work associated with AMAG for the remainder of the year.

2000

- January - The new Byron Engineering Director convened a meeting to resolve AMAG. An informal vote was made at the meeting to move forward with AMAG implementation, despite there being four technical individuals (including the Byron TPE) voting against this decision. The Corporate Lead was at the meeting

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but abstained from voting because he felt it was the site's responsibility. The prevailing thought for moving forward was that there was nothing identified as being wrong with AMAG technology.

- Byron engineering prepared a report for Byron senior management to recommend implementing AMAG. This report did not provide resolution of the secondary system indication issues and did not document the opposition of the technical individuals. Byron senior management approved the recommendation in March.
- April - The Byron Design Engineering Manager presented Byron's recommendation to implement AMAG to the NRG Senior Executive Team. The presentation did not include information regarding the dissenting opinions of Stone and Webster or the Dresden TPE, nor did it discuss the fact that the four technical individuals at Byron voted against implementing AMAG at Byron's meeting in January. The Senior Executive Team concurred with implementing AMAG at Byron.
- May - Byron implemented AMAG. AMAG, Inc. stated that they became so frustrated by repeated questions from Byron that they offered two days of training. This training was presented at Braidwood and was poorly attended.
- June - The Braidwood TPE wrote a letter concluding, "Enough indications (other than AMAG) exist which demonstrate that the Byron units are operating approximately 1.36% higher than the Braidwood units. However, based upon the single measurement of AMAG, all units indicate nearly identical thermal power levels. The possible conclusions are:
  3. AMAG is in error, or
  4. All of the other indicators are in error and in the same direction and of the proper magnitude.It is doubtful that item 2 above is true since it is unreasonable to assume that so many indications are in error, in the same direction and approximately in the necessary amount. Item 1 above raises doubt about our ability to correctly measure the actual thermal power levels at the Braidwood and Byron Units." The engineer recommended that an independent party with no vested interest in the outcome conduct a review of the data. No CR was written and no owner assigned to this issue.

2001

- October - Two CRs were written to address the power uprates at Braidwood and Byron and the impact this had on AMAG and subsequent power levels. One of the CRs was to resolve why following the uprates that Braidwood Unit 1 could achieve 100% power, but Byron Unit 1 could not. The corrective actions tied to this CR focused on what hardware or plant changes were needed to get Byron Unit 1 to 100%.

2002

- January - The Byron TPE generated a CR to document the unexplained differences between Byron and Braidwood. The supervisor reviewing the CR recommended an independent review of the condition, but the evaluation was assigned to the same TPE who generated the CR. An Apparent Cause Evaluation was initiated rather than a Root Cause Analysis. The NRC resident reviewed the CR and had questions regarding the differences between Byron and Braidwood.
- February - Two engineers from the Mid-Atlantic ROG were requested to perform an independent review of the AMAG issues. Their report concluded, "We agree with Byron Engineering and suspect that Byron Units 1 and 2 are operating at reactor power levels higher than indicated. This opinion is based on many indications, ...e.g., plant output and fuel burnup. ...However, we are not able to identify the cause nor to quantify amount. We also agree that the most likely fault is the AMAG correction factors... A more in-depth investigation should be planned... We fully expect that a full review of...AMAG implementation will ultimately identify the cause of the difference... THE TRUTH IS OUT THERE." Based on this report, the Byron Site Vice President had the AMAG correction factors removed, effectively de-rating each unit approximately 23 Mwe.
- Five days later, Nuclear Fuels Management (NFM) issued a letter stating, "...neither the differences seen in the development of reload cores nor the variations in cycle depletion data, since the implementation of AMAG, can confirm or repudiate the validity of the AMAG results." The AMAG correction factors were then re-Implemented based on NFM finding insufficient evidence to substantiate the MAROG engineers' fuel burnup issue.

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- July – At the request of the Byron Site VP, the Corporate VP of Engineering issued a letter summarizing corporate’s review of the AMAG issue. Conclusions include: the Byron installation was correct, the equipment was performing within specifications, the data was being properly interpreted, the correction factor and calorimetric were being properly calculated. Corporate engineering recommended continued use of AMAG at Byron.
- Summer – Byron TPE, several times, expressed concern to Nuclear Oversight Manager regarding the lack of progress in solving the Byron/Braidwood differences. No documentation of NOS follow-up was made.
- October - A draft copy of the ACE started in January was provided to the NRC Resident Inspector.
- November – The ACE started in January was completed, concluding that the apparent cause was indeterminate. PORC review of the ACE stated, “There is insufficient information to know if we are within the license basis....This could be a nuclear safety issue if an independent person disagrees with our conclusion.” The indeterminate ACE was approved by MRC and PORC, and no Root Cause Analysis was commissioned to identify the cause.

2003

- January – Westinghouse issued a letter to Byron recommending that AMAG data be collected for six months in order to enable a better evaluation to be completed. Six months of data had already been collected, but had not been transmitted to Westinghouse.
- January – NRC issued a letter to Exelon requesting additional information and stating, “Byron Unit 1 may be operating above its licensed thermal limit.” A CR was written the next day to document the NRC concerns.
- January – Exelon met with the NRC to assure them that Byron was not operating above its licensed thermal power.
- February – Exelon provided formal response to the NRC stating that AMAG was properly installed and functioning and that Byron Unit 1 was operating within its licensed power limit.
- March – In response to continued NRC concerns, Byron and Braidwood implemented additional feedwater flow measurement testing during various power maneuvers, in order to compare unit performance.
- April – NRC issued its inspection report for an Unresolved Item for the Byron power discrepancy, stating, “The inspectors considered the licensee’s evaluation to be of appropriate scope and depth. However, based on the potential for Byron Unit 1 to be exceeding the licensed thermal power limit, and the technical complexity of the issue, the inspectors requested that NRR conduct additional review.”
- May – August – Byron and Braidwood installed additional flow measurement instrumentation in order to better evaluate the discrepancy.
- July – NRC issued a second letter requesting additional information regarding the potential overpower condition.
- August – Westinghouse issued a letter documenting that feedwater flow on Byron Unit 1 was outside the acceptable statistical limits. Westinghouse/AMAG, Inc. noted that variations in flow measurements were associated with hydraulic noise contamination of the signals, affecting measurement results. Byron reset their AMAG correction factors for both units pending resolution of the issue. Byron notified the NRC of a potential violation of maximum power level on Units 1 and 2.
- August – Westinghouse/AMAG, Inc. noted some hydraulic noise on Braidwood Unit 1, but recommended that it continue to operate in its current condition based on additional data. Westinghouse recommended that AMAG correction factors for Braidwood Unit 2 be reset since hydraulic noise was present and additional data did not support continued operation with the AMAG correction factors. Braidwood complied with the Westinghouse recommendations, and notified the NRC of a potential violation of maximum power level on Unit 2.

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Attachment 3  
Identified Issue Handout

Name: \_\_\_\_\_

Location: \_\_\_\_\_

**Think back on the AMAG events and to consider whether you have any similar type concerns. Are there issues out there that have not been addressed to your satisfaction? From a personal standpoint, these could be in your area of ownership. From a fleet-wide perspective, the issues could be anywhere.**