INGAA

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VIA ELECTRONIC DELIVERY

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Re: Natural Gas – PHMSA's Valve Study – ORNUTM-2012/411 ORNUTM-2012/411: Requirements of Automatic and Remotely Controlled Shutoff Valves on Hazardous Liquids and Natural Gas Pipelines with Respect to Public and Environmental Safety

Comments from the Interstate Natural Gas Association of America on Draft Research Report

Dear Sir or Madam:

The Interstate Natural Gas Association of America (INGAA)[1] appreciates the opportunity to comment on draft research report ORNUTM-2012/411 (Draft Report). INGAA believes it is critically important that PHMSA have comprehensive and quality information being used in its deliberations. As such, INGAA is committed to constantly improve the information quality that it supplies to PHMSA and review the quality of the information provided by others. INGAA has directly commented on this subject of Remote and Automatic Valves at the PHMSA public meeting on March 27, 2012 and has supplied additional comments to the public docket on this subject on April 30, 2012.

To an extent, developing comments on the Draft Report was hampered by the amount of time allowed.[2] Within the time given, INGAA compiled various comments from its membership and assembled them here in an effort to offer articulate, professional, technical criticism of the report's assumptions, methodologies, accuracy, use of data and conclusions.

INGAA limits its review to the portions of the Draft Report that apply to the natural gas transmission pipeline system. Our reviewers have not attempted to address any issues with characterization and analysis of subject as it pertains to hazardous liquid pipelines and gas distribution**.**

Background

For the past several years, the INGAA and its members have been developing and following a systematic process, known generally as Integrity Management Continuous Improvement (IMCI), to improve the integrity of the interstate natural gas transmission system. The overall goal of the IMCI process is zero incidents. To achieve that goal, INGAA and its

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1 INGAA is a non-profit trade association that represents the interstate natural gas transmission pipeline industry. INGAA's members, which represent approximately two-thirds of the pipelines and over 65 percent of the mileage comprising the U.S. natural gas transmission pipeline system, are subject to comprehensive safety regulation by the Pipeline and Hazardous Materials Safety Administration (PHMSA).

2 The draft report was made available and presented via a webinar on October 4, 2012, with comments due October 26, 2012.

members have instituted a system for reassessing individual processes, ranking them in priority, and applying management system methodologies to improve performance.

Under IMCI, INGAA reassessed the processes and practices members have implemented in response to ASME B31.8S, the PHMSA integrity management regulations that were modeled after that standard, the legacy PHMSA pipeline safety regulations that have been in effect since 1970, and the results of those implementations.

Two areas of effort are particularly related to this research report. The primary goal is to assess the risk of failure to manage the integrity of the pipeline before there is an unintentional release of natural gas, Integrity Management Program (IMP). The second goal is to help manage the consequences of an unintentional release through Incident Management Mitigation (IMM). INGAA has directly commented on this subject of Leak Detection at the PHMSA public meeting on March 27, 2012 and has supplied additional comments to the public docket on this subject on April 30, 2012.

General Comment

The researchers at the Oak Ridge National Laboratory (ORNL) agree with all the prior reports from GRI, PRCI, INGAA, PHMSA and RSPA: Valve automation can help protect some property by allowing earlier firefighter access, but does little to protect people. Echoing a point INGAA raised in its "policy level" comments on PHMSA's advance notice of proposed rulemaking for natural gas transmission, page 6 of the Draft Report notes that most of the human impacts from a rupture occur in the first few seconds, well before any valve technology — including remote and automatic shut-off technology — could reduce the flow of natural gas:

> Blast, overpressure, shrapnel, and earthquake-type effects resulting from an unintended natural gas or hazardous liquid pipeline release are hazards that can adversely affect humans, property, and the environment. However, these effects are beyond the scope of this study because they occur immediately after the break and RCV s and ASV s, which typically require several minutes to close, cannot mitigate these hazards.

Further recognizing the limitations on automatic shut-off valves (ASVs) and remote control valves (RCVs), as well as the industry reports that identified them, page 3 of the Draft Report appropriately takes issue with a contrary determination the National Transportation Safety Board (NTSB) made in its report following the San Bruno, California incident:

> *The NTSB determined that the damage caused by the pipeline rupture could have been significantly reduced with the use of ASV s or RCV s and that the industry references for the evaluation of ASV s and RCV s are flawed. These industry references conclude that the majority of damage caused by a pipeline rupture occurs within the first 30 seconds and the duration of the fire's threat to human safety and property damage is minimal.*

Specific Comments

1. *Misunderstanding the Potential Impact Radius (PIR)*

The PIR methodology was designed as a screening tool to determine areas of high consequence. The calculation estimates the potential impact area of 1% lethality for an accumulated thermal radiation dose by persons in an open area(see GRI 00/0189 p8). The PIR methodology estimates damage to a hypothetical human by integrating the accumulated dosage as the exposed person escapes from the fire to find shelter.

The PIR methodology was calibrated to a dozen actual fires and includes the 36" pipe fire experiments discussed by the Acton references on page 187. Additionally, the PIR calculation does not estimate the extent of fire damage. It was never intended to be a transient flow model nor was it ever to be used as a thermal radiation model. Unfortunately many readers tend to over simplify the concept and leap to the incorrect conclusion. Users need to take time to read and understand the PIR report GRI00/0189.

It appears the authors misunderstand this concept.

2. *Inaccurate Severe Damage Diameter Assumptions*

On page 10 of the Draft Report, a table describes the radiant heat flux in order to cause ignition in materials that could be a structure in a fire that resulted from the rupture of a natural gas transmission pipeline. These values were obtained from various documents in which materials were tested under certain controlled, constant thermal flux conditions. The prediction of the time for the material to ignite is a function of the time for the surface of the solid to heat and begin to gasify and the presence of a pilot ignition source to ignite the gaseous fumes. Many variables enter into that determination. Unfortunately, this table depicts steady state behavior of material under these heat fluxes, not the actual transient behavior of a natural gas pipeline rupture.

The entry of 39.4kW/m2 by the Joint Fire Research appears to be very close to the assumed value used in the analysis case of severe damage (page 41) by the authors. The authors describe the Severe Damage diameter as a location where almost instantaneous ignition occurs. As stated in Table 1.1, these research values are useful in the analysis of piloted ignition situations. The same source states that substantially higher levels of heat radiation are needed for spontaneous combustion (no pilot ignition needed). That means that unless there are open flames near the material, it will not ignite but would gasify and char, at that this referenced heat flux (39.4) in a short period of time.

This is in contrast to the transient nature of the natural gas transmission pipeline rupture. The progress of a full guillotine fracture of a buried high pressure natural gas pipeline with almost immediate ignition follows these steps:

- The overburden over the pipeline is ejected from the crater by the high pressure gas released from the pipe interior, expelling the overburden as shrapnel. The associated pressure wave is able to break nearby windows, and scouring the dirt forming a crater shape. The gas initially escapes to the atmosphere at the highest flow rate (sonic velocity). This crater shape is somewhat influenced by the orientation of remaining pipe stubs within the crater from which the gas is escaping. The two streams of gas and the shape of the crater significantly forces the direction of the gas into a vertical column and in some cases when the flow from one side decreases faster the other jet changes the fire direction to drop from vertical to a high angle now directed parallel to the pipeline ROW.

- In documented cases, this initial escaping gas displaces the air and forms a dome shaped cloud that rises quickly following a spherical capped bubble shape, pushed by buoyancy and the velocity of the gas jet directed up from the crater. Ignition of the natural gas occurs on the outside diameter of the dome shape where there is a gas/air interface. Depending on the ignition time, the height of the silo shaped dome is different. After ignition, the flames completely encircle the silo shape. Additional heat generation adds to the upward buoyancy velocity of the escaping gases as the silo shape slims up forming a mushroom cloud that becomes a more stable burning columnar shape.

- As the fuel source in the two pipeline stubs choke down due to friction in the pipeline, pressure discharge reduces while new gas continues to flow in from the upstream and downstream pipeline reservoirs. The gas emerges at sonic velocity causing the typical jet engine noise from the pipeline. The pressure/flow rate drops significantly with time. The pressure is dropping down the near sections of the pipeline reducing the volume of the fuel gas exiting the crater over time, quickly reducing the height of the flame over the next few minutes. These fires are still huge but the flow rate drops to half within about 10 minutes.

The ignition of materials around the crater is dependent on the integration of the instantaneous heat flux over time, the amount of time, and the presence of a pilot ignition source. The dosage is this measurement of the accumulated heat energy with time.

It appears that that the authors have grossly overestimated the Severe Damage Diameter that they are using in the model by mis-utilizing the constant flux 40 4kW/m2 radiant heat flux. The heat flux value for buildings that the authors are using from the NFPA sources is based on steady state and piloted ignition.

The ignited exterior of the mushroom cloud as it rises from the surface will pilot ignite lighter materials as it sweeps back over the surface. These susceptible preheated surfaces and lighter materials immediately ignite over a large diameter.

The piloted ignition sources emanating from the fire origin extend in distance over a period of time as nearby ignited sources(houses) preheat and ignite new neighboring surfaces that have absorbed enough heat over time per table 1.1. The actual size of the Severe Damage Diameter is significantly smaller that ORNL estimates. The greater of the these two values, the diameter of the silo shaped cloud of the initial rupture which would cause piloted ignition or the diameter of the spontaneous ignition heat rate should be chosen as the Initial Damage Circle diameter. The PIR is a realistic estimate of both human survivability and piloted ignition that has been calibrated. ORNL has picked a different threshold.

The nomenclature of the circles in the author's modeling should be more accurately described as initial, intermediate and advanced event time frames since the event timeframe may not align linearly with the severity of the consequences.

3. Optimistic Leak/Rupture Detection Time

The authors are assuming an optimistic time to detect a rupture on a natural gas transmission pipeline. The companion draft research report (DTPH56-11-D-000001) on leak detection attempts to estimate the detection time, unfortunately the analysis of that report is muddled by the inclusion of leak events which obscure the performance of critical rupture events. If this data is filtered for just rupture events which are the major concerns of valve closure, a more accurate representation of the detection times of a rupture (no matter the source of information) would be available for use in this report. The reasons for slower detection response times on natural gas transmission pipelines are listed below:

- SCADA uses pressure drop differentials and the long distances between compressor stations or MLV pressure sensor locations make it difficult to detect ruptures in a timeframe assumed in this report (less than the 10 minute emergency response stated in the report).

- Isolation of a pipeline section requires assessment of all the fuel inputs (multiple pipeline or sources) to the rupture/leaking section and this control room analysis is not instantaneous nor are all the sources controlled by automatic or remote valve operators but they may have manual or check valves.

- The physics of the natural gas release rates to supply fuel to the fire at the rupture point causes the flow to drop approximately to about 20% of the initial rate in 20 minutes which is well before the valves have been closed.

4. New Thermal Flux Criteria

In this report, the authors have arbitrarily introduced new thermal flux criteria for property damage, no longer related to lethality, but to a threshold based on a steady state thermal flux in a NFPA standard for piloted combustion. Unfortunately natural gas ruptures and the resulting fires are not steady state but transient and are highest immediately and quickly drop in magnitude. The second point is the author assumes that there is piloted ignition at the beginning of the event. Arbitrarily introducing a new steady state thermal radiation flux criteria based solely on opinion makes it difficult to provide comparisons. The new ORNL criteria are set out in table 1.2 and are not based decreasing thermal radiation exposures.

The graphs were plotted using the PIR to normalize distances. Since the PIR requires an integral of thermal radiation over the initial time period and the ORNL calculation provides an instantaneous thermal radiation flux with time, this attempt to normalize distance is grossly misleading. These graphs should be re-plotted correctly.

ORNL reviewed API 521 but again decided to use other criteria however they are not much different. See page 21 & 22 table 1.2 in their report and associated text. In effect they chose their own criteria from consideration of literature. GRI used API 521's 500 BTU/h-ft2 for working and ORNL chose 400 BTU/h-ft2, [3] while GRI used API 521's 1500 BTU/h-ft2 as a short duration working time and ORNL chose 800 BTU/h-ft2[4] for continuous exposure in proper equipment.

People and property damages are included in the definition of PIR basis in 192.903 which defines the potential impact radius as" the radius of a circle within which the potential failure of a pipeline could have significant impact on people or property." Both people and property are significantly impacted inside the PIR circle. People are estimated to escape but can be exposed to a significant thermal radiation flux causing 3rd degree burns and it models1% lethality. Property is exposed to a flux in excess of 5,000 BTU/h-ft2 which is accepted as the thermal flux needed for the piloted ignition of a wood 2x4. Thermal radiation comes from the natural gas fire. Initially the exterior of the spherical cap, burning gas cloud, rising from the ground will ignite all combustible materials within a large diameter. The intense initial radiation flux at the beginning of the gas fire preheats the adjacent surfaces and once they exceed the dosage they are susceptible to piloted ignition (Stephens page 189 table 2.2). This initial gas fire ball also starts a ground fire. The ground fire also ignites the preheated surfaces. Any new thermal flux criterion is unnecessary.

The PIR methodology was calibrated to a dozen actual fires and includes the 36" pipe fire experiments discussed by the Acton references on page 187. Additionally, the PIR calculation does not estimate the extent of fire damage. It was never intended to be a transient flow model nor was it ever to be used as a thermal radiation model. Unfortunately many readers tend to over simplify the concept and leap to the incorrect conclusion. Users need to take time to read and understand the PIR report GRI00/0189.

The PIR, as a regulatory unit of distance, could be used to normalize the ORNL calculations of the distance to the thermal flux criteria (in Table 1.2) with time. Having expressed the PIR as a regulatory distance in the graphs of the draft report, ORNL underlines how large these fires really are and emphasizes why the fire fighters need to establish large perimeters, in the order of several blocks. The thermal radiation at a distance can be calculated and these graphs need to be redone to express these concepts correctly.

The ORNL graphs confirm that fire and thermal damage occurs beyond the PIR. It is incorrect to think that the PIR is the maximum perimeter of fire damage caused by the natural gas fire. The PIR calculation does not estimate the full extent of fire damage. It was never intended to be a transient flow model nor was it ever to be used as a thermal radiation model. Unfortunately many readers tend to over simplify the concept and leap to the incorrect conclusion. Users need to take time to read and understand the PIR report GRI00/0189.

5. Lack of Impact Methodology Validation

The San Bruno estimate example (fig 3.68) suggests that the new ORNL criteria of 800 BTU/h-ft2 radiation flux magnitude for fire fighters extends almost 3.5 the 411 ft PIR or almost

[3] The 450 BTU/h-ft2 comes from HUD 201 1b. (HUD refers to the US Department of Housing and Urban Development).

[4] The 800 BTU/h-ft2 comes from NFPA GUIDE FOR FIRE AND EXPLOSION INVESTIGATIONS (NFPA refers to the National Fire Protection Association).

¼ mile about 20 minutes after the fire. The ORNL 5,000 BTU/h-ft2 curve suggests that the initial distance for piloted ignition of wood extended out 1.7xPIR or 700 ft. However the property damage from the natural gas fire to the south was just within the PIR of 411 foot in figure 3.69. San Bruno is a poor example because the fire was in the bottom of a bowl and the distance from the houses around the top of the bowl to the radiation source was much less than the flat surface assumptions require by the calculations. The wind drove the ground fire to the NE. The tightly spaced housing allows the fire to preheat and jump to adjacent neighboring houses.

The PIR methodology was calibrated to a dozen actual fires and includes the 36" pipe fire experiments discussed by the Acton references on page 187. The calculated outcomes in the ORNL model therefore seem excessively conservative and they exclude the lethality relationship.

6. Optimistic Fire Mitigation Assumptions

Even with firefighter intervention, unless firefighters are able to arrive on scene and are ready to fight the fire in 10 minutes the benefits are greatly reduced. These key conclusions should be made much clearer in the executive summary and other high visibility locations in the report how the benefits change based on this assumption. It stated throughout the report that there is no benefit unless firefighters arrive and are ready to initiate firefighting activities in 10-20 minutes. Most of the natural gas transmission pipelines are in rural areas however the 20 minute assumption might be possible in suburban or higher population densities. The estimated number of fire hydrants seems optimistic and this optimism improves firefighting capability for benefit analysis.

Per the NTSB report on the San Bruno incident, the rupture occurred at 6:11pm and the fire hydrants were reported dry at 6:24pm. In this situation, the firefighters were approximately 300 yards away from the rupture location when the incident occurred, so even in this extreme close proximity to incident it took 13 minutes to prepare to initiate firefighting activities. It is understood that unfortunately the first fire hydrants in the San Bruno incident were dry and were not able to be used, but were they not this appears to confirm that 10 minutes is extremely optimistic and that in most circumstances firefighters will not be located so close to the incident.

7. Overly Conservative Assumptions on Property Impacts

The inherent design of the methodology and assumptions by the authors result in a severe impact radius that exceeds the present PIR radius. Since the information outside the PIR is unknown to the authors, they assume a significant increase in population density outside the PIR as compared to inside the PIR. If the heat fluxes are corrected, the impact to the population groups outside the PIR will be due to piloted ignition during the intermediate and advanced in the time line of the event, when emergency response is in place.

8. Inaccurate Benefit Analysis

Page 177 of the Draft Report suggests that from the standpoint of property loss there is no advantage to closing a block valve swiftly:

> The risk analyses show that there are no avoided costs for fire damage to buildings and property attributed to block valve closure swiftness because potentially severe damage occurs before block valve closure can isolate the damaged pipeline segment and begin limiting the amount of natural gas that escapes and burns.

There is some advantage from earlier closure of a valve in that the emergency providers can begin to fight the secondary fires during the intermediate and advanced stage of the incident and mitigate the total damage. However the majority of the property damage has already occurred before the fire fighters arrive and respond.

9. Cost Benefit Analysis

Page 173 of the Draft Report The report confirms there is a marginal cost benefit for installing additional valves however quick response may help to restrict the eventual extent of the ground fire:

> Risk analysis results discussed in Section 3.1.4 show that without fire fighter intervention following natural gas pipeline releases, the swiftness of block valve closure has no effect on mitigating potential fire damage to buildings and personal property in HCAs. Block valve closure swiftness also has no effect on reducing building and personal property damage costs because thermal radiation is most intense immediately following the break. Consequently, without fire fighter intervention, there is no quantifiable benefit in terms of cost avoidance for damage to buildings and personal property attributed to block valve closure swiftness in natural gas pipelines. However, when combined with fire fighter intervention the swiftness of block valve closure has a potentially a potentially beneficial effect on mitigating fire damage to buildings and personal property in HCAs.

Most of the savings are based on being able to close the main line valves in 8 minutes or 13 minutes, which is far earlier than normal past experience. The savings go to zero as the time interval to the valve closure gets longer. Consequently, without fire fighter intervention, there is no quantifiable benefit in terms of cost avoidance for damage to buildings and personal property attributed to swiftly closing block valves located upstream and downstream from guillotine-type breaks in natural gas pipelines.

10. Significant Over Conservativeness in the Benefit Determination

Avoided fire damage seems simplistic especially assuming a constant heat flux. In reality the heat flux continuously decreases and decreases rapidly until about 30 minutes and then becomes asymptotic unless valves are closed earlier. Realistically the probability of no ignition and a range of damages should be included to assure the benefit will be accrued. Not all ruptures ignite; the probability is a function of diameter and pressure.

INGAA also notes that Tables 3.10 & 3.11 have typos and should say identified sites, not 4 story buildings.

The cost saving due to earlier fire fighter access and their mitigation of the damage is under $6 million in all the examples. While the damage percentage might be small to the operator, the loss of each house to the individual owner is catastrophic. This difference in perception needs to be addressed.

Therefore ORNL confirmed that advantage of faster valve operation and closer valve placement has almost no effect on the total damage estimate.

11. Underestimation of Valve Costs

The authors utilized varied information to come up with costs. It appears that there is a gross underestimation of the cost of the refitting of an automatic valve. INGAA is providing updated information that was presented at a Southern Gas Association webinar.

Cost to install a new valve

Install a New Valve						
Item	12" Valve		30" Valve		42" Valve	
	Low Case	High Case	Low Case	High Case	Low Case	High Case
Install new valve	150,000	170,000	400,000	420,000	650,000	670,000
Actuator	-	30,000	-	80,000	-	120,000
ASV System	30,000	-	30,000	-	30,000	-
RCV Adder	-	100,000	-	100,000	-	100,000
Alternate Power	-	25,000	-	25,000	-	25,000
Reserve Gas Bottle	-	5,000	-	10,000	-	15,000
Building	-	15,000	-	15,000	-	15,000
Total with new valve	**180,000**	**345,000**	**430,000**	**650,000**	**680,000**	**945,000**

Conclusion

While INGAA would have appreciated more time to examine and critique the Draft Report, we realize that the effort to address some of the major issues will be widespread and will require an extensive effort by the authors. We think it is expeditious that these issues be exposed quickly and that the paper be redrafted by the authors based on the reanalysis of these issues and be resubmitted to PHMSA and the public for review. Additionally, we strongly urge that in future study updates that the researchers acknowledge and use the full breadth of information available from the public and industry sources, and if there are questions on the accuracy of such information, then additional clarifications be requested.

Respectfully submitted,

/s/
Dan Regan
Regulatory Attorney
Terry D. Boss
Senior Vice President of
Environment, Safety and Operations
Interstate Natural Gas Association of America
20 F Street, N.W., Suite 450
Washington, DC 20001
(202) 216-5900