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Commentary on the Risk Analysis for the Proposed Emera Brunswick Pipeline Through Saint John, NB

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October 18, 2006

This document is based on an evaluation of information readily available and in the public domain.

Table of Contents

Table of Exhibits

I. Executive Summary

Accufacts Inc. has been asked to comment on the recent Risk Analysis ("RA") performed on the proposed Emera Brunswick Pipeline route through Saint John, New Brunswick by the Saint John Fire Department.[1] In a previous independent report concerning this proposed high pressure gas transmission pipeline through the city of Saint John, Accufacts concluded: "For most gas transmission pipelines, the large thermal impact zones generated from early (within minutes) ignition sets the "controlling case" defining the potential impact zone. Accufacts must advise that over reliance on Emergency Response Planning ("ERP") utilizing Emergency Planning Zones to reduce risk will prove highly ineffective during the high heat flux stages of early ignition for a pipeline rupture. As clearly demonstrated in this report, no credit for risk reduction should ever be taken in risk analysis for such efforts."[2] This document will illustrate in further detail the harsh realities associated with this statement.

Accufacts Major Findings on RA

ERPs are never to be used as credit against the real risks of poor pipeline siting.

The rupture mass release over time curve for the City segments needs further clarification.

Remote valve spacing does not reduce the major risks from gas pipeline release.

Valve spacing does not compensate for poor pipeline route selection.

The pipeline applicant has not provided proper rupture heat flux vs. distance plots required in any complete siting analysis.

Acceptable survivable heat flux (KW/m^2) limits have not been adequately defined.

A 300 m Potential Impact Zone value is not appropriate for this pipeline in the City.

Aerial maps with proper concentric heat flux isopleths have not been developed.

ERPs are needed to insure adequate First Responder effectiveness.

Accufacts supports many of the major findings and recommendations in the above referenced Fire Department Risk Analysis. Our major differences related to the RA on this unique gas transmission pipeline are briefly listed in the textbox "Accufacts Major Findings on RA," and summarized in further detail in Section VII of this report. Certain technical specifics presented in this report will further demonstrate the reasons that caution and prudence be exercised in the siting of new large diameter high-pressure gas transmission pipelines in the proximity of sensitive receptors, such as high population density. While our focus is clearly on the proposed Emera Brunswick Pipeline, the general principles and processes presented in this paper should apply to siting of all

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[1] "Risk Analysis of Emera Brunswick Pipeline Company Ltd.'s preferred natural gas pipeline corridor through The City of Saint John," prepared by the Saint John Fire Department, issued September 22, 2006, revised September 26, 2006.

[2] Richard B. Kuprewicz, "An Independent Analysis of the Proposed Brunswick Pipeline Routes in Saint John, New Brunswick," September 16, 2006, page 1.

large diameter high-pressure gas transmission pipelines.

Our analysis is by no means meant to be critical of the Fire Department, as the concepts presented here are highly specialized. Even most pipeline operators are unfamiliar with the unique and highly technical details and processes summarized in this document. It would be fair to assume that Accufacts has considerable field experience in first response associated with unique energy infrastructure. In all of these actions, the author has been guided by the simple principle that first responders and operators are paid to save lives, not to die while trying.[3] The reader of this report should rightly conclude that many lives have been saved throughout our extensive thirty plus year career, and these situations were not staged training drills.

> Proper ERPs are needed, but should never be sold as "credit" to justify poor pipeline siting/ routing choices.

Lastly, this author must stress the importance and support to develop, incorporate, and apply appropriate ERPs to handle major emergencies. Such plans play a significant role in insuring sufficient first responder equipment, manpower, and training are available in the event of a pipeline release.[4] These plans, however, should never be utilized to credit or reduce the risks associated with gas transmission pipeline rupture failures, or to justify poor pipeline route selection. ERPs may be effective in saving first responders and some outlying receptors (the secondaries), but are ineffective for those main receptors (the primaries) caught in the fast acting high thermal dosage zones associated with high probability of fatality from a pipeline rupture.

The color photo on the cover of this report was taken during the Edison, New Jersey gas transmission pipeline rupture in 1994 (36 inch, ~970 psig). This jet fire lasted for approximately 2 ½ hours. Given the flame length shown in the photo, it would be fair to assume this picture was taken at a much later time following pipe rupture. While photos can't always gauge perspective properly, one could conclude the fire truck is too close, a situation this author has observed too often. Edison represents a sea change in the learning curve for many first responders and many gas transmission pipeline operators in the U.S.

II. Gas Pipeline Rupture Failure Dynamics

Readers should gain a clear appreciation of the failure mechanism associated with the worst case scenario of a gas transmission pipeline, a pipeline rupture, as it can be easy to misrepresent or underestimate this failure mode. Too many engineers mischaracterize gas pipeline ruptures as a "guillotine" break which may suggest to a layperson a

[3] While this principle should seem obvious, it is so important that it is codified in prudent pipeline safety regulations.
[4] See "An Assessment of First Responder Readiness for Pipeline Emergencies in the State of Washington," prepared for the Office of the State Fire Marshall, by Hanson Engineers Inc., Elway Reasearch Inc., and Accufacts Inc., dated June 26, 2001.

somewhat lower probability occurrence as pipe doesn't usually guillotine. Accufacts prefers the use of the term "full bore release" rather than guillotine to more accurately portray this failure and its subsequent gas release mechanism to the public.

It is the nature of high-pressure large diameter gas transmission steel pipelines that they are all capable of rupture failure, in which a smaller anomaly grows to a defect causing the pipe to rapidly unzip or shrapnel fracture (usually in microseconds) along the length of the pipeline.[5] Such rupture fractures can propagate many feet down a gas pipeline before the fracture energy is dissipated. This fracture mechanism is driven largely by the highly compressible nature of the gas.[6] The resulting rupture failure leaves a full bore opening in the pipeline with gas roaring out both ends of the remaining pipe.[7] Regardless of the length of the rupture failure along the pipeline, all high-pressure (i.e., high stress) large diameter gas transmission pipeline ruptures release gas as double full bore failures. The fracture mechanics for certain types of anomalies (i.e., corrosion) have been well understood for many decades, especially for gas transmission pipelines. No high stress steel pipeline is invincible to pipeline rupture, if the wrong anomaly or conditions become present.

> All high-pressure large diameter gas transmission pipeline ruptures are double full bore releases.

Girth weld failures also exhibit gas release as a rupture if the weld has fully separated along the full circumference for various reasons (e.g., poor weld, abnormal loading, intentionally designed "weak point"). Girth weld failures could be classified as a "guillotine" type failure as in many cases these failures represent clean separation failure along the entire girth weld. To minimize such girth weld failures, many new pipe installations wisely "radiographically" inspect all welds even though such a requirement may not be mandatory in a specific country's pipeline regulations.

III. Gas Rupture Transient Mass Release Rate Curves

Upon rupture of the pipeline, the gas within the pipe, specifically at the bore exit at each end of the pipeline segments across the opening, rapidly increases to sonic velocity (the speed of sound of the gas at the specific temperature, usually on the order of 1,100 plus

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[5] An anomaly is an imperfection in steel pipe or pipe welds (not usually through the pipewall); a defect is an anomaly that has grown to sufficient size to permit pipeline failure and release, either as a leak or a rupture. All pipelines contain anomalies, and most anomalies do not go to failure, and thus are not a risk of concern.
[6] Modern liquid pipeline ruptures don't usually tend to promulgate (fracture) down the length of the pipeline, rather they tend to "fishmouth," because the liquid is orders of magnitude less compressible than natural gas.
[7] Technically, the fracture may not be a clean circumference break as the pipe tears which can leave parts of the pipe, but for flow calculations the rate of mass release will be very similar to a "clean" circumferential break given the very high release mass rates.

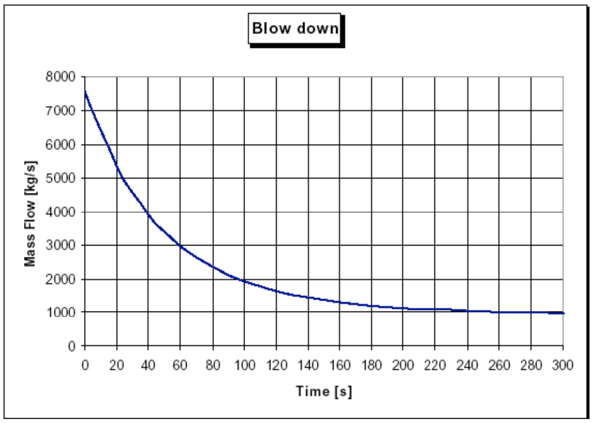

Figure 1: Bercha QRA Mass Release Over Time for Rupture within City Segment

ft/sec) as the pipeline starts to de-inventory. While the velocity of the gas exiting out each bore is set or "choked" by the laws of thermodynamics to sonic velocity, the mass rate of gas release changes with time and is driven by the density of the gas directly upstream of the bore, and this density declines or decays as pipeline pressure decays. The mass release over time from both ends of an open pipeline are added and plotted as shown in Figure 1, which was taken from the pipeline Applicant's QRA.[8] This figure represents the Applicant's "typical" mass rate decay for a rupture in a segment of the proposed pipeline within the limits of the city of Saint John. Note that the mass rate of release for a rupture is a peak value at initial rupture determined by the pipeline diameter and the system pressure <u>at the time and at the point of the pipe failure</u>. This peak mass rate of release then decays over time, with the slope of the decay from the initial peak mass rate of release dependent on various system factors such as the friction factor of the pipeline, the length of upstream/downstream pipeline segments (affects gas inventory), as well as placement and operation of upstream/downstream compressors and their operation. <u>The pipeline operator has not made clear whether the curve in Figure 1 represents the maximum future capacity of this pipeline, a very important consideration in pipeline routing and potential impact zone evaluation.</u>

At the operating pressure for the proposed Emera Brunswick Pipeline, the inventory within the pipe <u>**exceeds 42 tons of gas for every mile of pipeline**</u>. It will take a very long time to truly de-inventory the pipeline during a rupture failure even with the gas venting at the speed of sound. Once a gas pipeline rupture has ignited (most do), the only appropriate emergency procedure is to safely extinguish the flame by fuel cutoff (via pipeline valve closure), and allowing the flame to burn itself out from lack of fuel.

> No effort should ever be made to attempt to extinguish a burning gas transmission rupture fire, because of the exposure of re-ignition and possible explosion from another high mass release.

Judicious placement of <u>remote</u> operated valves can reduce total blowdown time for various pipeline segments, especially as the decay curve can extend into many hours for long pipeline segments. Segmenting, by adding additional valves, reduces the amount of gas that may have to be de-inventoried or blown down for particular pipeline segments.

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[8] Application to the National Energy Board, Appendix A5, Bercha Group, "Quantitative Risk Analysis of the Brunswick Natural Gas Pipeline – Final Report," February 14, 2006, page 4-10.

Valve placement does not reduce the potential impact zone associated with the high heat fluxes related to gas pipeline rupture as discussed in the next section. Additional valving does not reduce the fatality/serious casualty potential impact zone connected with high heat flux, but valving, especially remote operated valves, can shorten the time to extinguish a gas pipeline fire, thus permitting first responders to move more quickly and safely into these disaster zones to initiate search and possible rescue of causalities. Referring back to Figure 1, adding remote operated valves does not change the shape of the blowdown curve (either the peak or slope of the line) in the early stages of rupture that define the potential impact zones. Note that in Figure 1, even after five minutes, the gas is still venting at 1000 kg/sec (no small value). Additional remote operated valves within the city may be justified if the activation time could be reduced to allow first responders to enter the area within ten minutes versus say fifteen minutes. Such valving will not, however, reduce the potential impact zone that is important in pipeline route considerations.

The pipeline operator has indicated in their Application that all valves on the pipeline will be remotely operated. The Fire Department analysis also indicated that the pipeline, including the remote operated valves, are to be operated from a centralized control center in Houston, Texas via SCADA.[9] The Bercha QRA supplied with the Application has also indicated that remote valve operation will not occur for at least fifteen minutes. We concur with the observation of the Bercha QRA concerning the minimum time required for valve closure activation. In a true emergency, time can pass very quickly and fifteen minutes, in this author's opinion, is realistic, reflecting an honest appreciation of the realities/complexities. For example, because of system dynamics, it is more likely than not that pressure loss will not be the primary or timely indicator of a gas transmission pipeline rupture.

> Pipeline routing decisions counting on ACVs to introduce safety or reduce risks, represent very poor engineering and pipeline management that should call into question any pipeline route selection / determination process.

One could argue that faster valve closure could occur if Automatic Closure Values ("ACVs"), valves that close without a remote command based on various field sensor inputs, might reduce the blowdown time and permit earlier entry by first responders into the zones. ACVs have been the topic of much debate within the industry for many decades. The author is of the opinion that ACVs on large diameter high-pressure gas transmission pipelines are ineffective in truly reducing potential impact zones. ACVs also introduce other complex risks to the pipeline operation that can cause system failure. A review of the rupture mass release curve in the early stages of release, shown in Figure 1, demonstrates just one reason for Accufacts' position on ACV ineffectiveness.

Depending on how one accounts for various pipeline system factors, there can be a range in the release mass release curves associated for a pipeline diameter. Based on this

[9] SCADA is an anachronism standing for Supervisory Control and Data Acquisition, basically a computer system to monitor and remotely operate the pipeline from a centralized location.

author's experience, the release curve depicted in the pipeline Application/Bercha QRA is not indicative of a conventional 30-inch pipeline, but is a fingerprint more characteristic of a rupture associated with a larger diameter conventional steel pipeline (e.g., 36 to 42 inch). The Applicant/Bercha QRA's analysis is moot on several specific critical inputs utilized to develop their rupture mass release over time curve. Even taking into account various system transients, the mass release is not what we would expect of a conventional 30-inch steel pipeline. The reduced friction factor associated with FBE coating on the inside of the steel pipe may play a role in the Applicant's increased mass release curve.

It is the Applicant's responsibility to clearly explain and defend their worse case rupture mass release curve, that is so important in evaluating potential impact zones.

IV. Heat Flux Phases of a Gas Pipeline Rupture

To truly appreciate and understand the potential impact zones associated with gas transmission pipeline ruptures, an understanding of the incredibly high heat fluxes associated with ignition, especially early ignition, of the gas cloud release needs to be gained. Given the high mass rate of release and sonic velocity of the gas, momentum forces for rupture releases are quite large, thus large craters are usually formed by the gas jets roaring out the bores of the pipe. Even this large horizontal momentum is quickly transformed, as buoyancy forces cause the gas mass to rise vertically into the air (natural gas being lighter than air). Upon ignition of the vertical gas cloud, two heat release phenomena take place: an extremely high heat flux "fireball" radiation burst associated with the initial ignition and rapid combustion, usually burning within thirty seconds, followed by a less rapid combustion vertical "jet fire" associated with decaying heat flux radiation.

During the initial fireball phase a large mass of mixed unburned accumulated gas is rapidly consumed. Fuel consumption and heat release of the cloud mass exceeds the rate of gas leaving the pipeline that is feeding a cloud of turbulently mixed air/fuel. Usually within seconds, the fireball transitions into a vertical jet fire. Throughout the much longer duration jet fire phase, fuel consumption and heat flux are essentially in balance as combustion is a function of the mass rate leaving the pipeline, which decays over time. Depending on various factors, there is usually a wide range of heat flux values associated with the fireball phase, on the order of 150 KW/m^2 to 300 KW/m^2.[10] Heat fluxes associated with the jet fire usually start at approximately 60 - 80 KW/m^2 and decline as the rate of fuel supplied from the pipeline decays with time.

In layman's terms, the jet fire phase usually defines the large controlling distance for heat flux survivability (dosage) when establishing rupture potential impact zones.

[10] "Report on a second study of pipeline accidents using the Health and Safety Executive's risk assessment programs MISHAP and PIPERS," prepared by Casella Scientific Consultants for the Health and Safety Executive 2002.

Many factors can change the magnitude of the above heat flux values. As will be demonstrated in the next section, at these high heat flux values such variation isn't really going to change the determination of very large potential impact zones. Technically, large diameter high-pressure gas transmission pipeline ruptures don't ignite or burn as flash fires.

Figure 2: Ghislenghien, Belgium Gas Pipeline Rupture Jet Fire

It is normal when evaluating potential pipeline routes to perform heat flux analysis, plotting heat flux associated with expected jet fire impacts versus distance, developed from the mass rate of release curve assuming jet fire heat flux. The fireball phase occurring in the early seconds is usually not shown, but depicted as a gap in the y value (asymptote) of the heat flux plot. Even though fireball heat fluxes are incredibly high, the short duration of this phase does not usually change the controlling case defining the large potential impact zones. Extremely high heat flux fireball considerations may enter into a route evaluation/consideration if a pipeline route is too close to school fields or other areas that may contain large numbers of unsheltered individuals, or other sensitive receptors most at risk during a rupture.

This author does not advise ignoring fireball heat flux effects but, in most cases, the vertical jet fire heat flux will be the controlling case in ascertaining pipeline routing and receptor survivability. A classic example demonstrating how a rupture can engulf unsuspecting victims that are too close to a pipeline rupture is shown in the July 30, 2004 gas transmission pipeline rupture failure in Ghislenghien, Belgium (40-inch outside diameter with 0.5 inch wall thickness gas transmission pipeline operating at 1160 psig). See Figure 2 for the jet fire associated with this rupture.[11] Five of the twenty-four deaths (there were 150 additional casualties) associated with this pipeline rupture failure, were fire department personnel who had responded to an initially reported gas leak emergency and were setting up safety barricades some distance from the leak, a typical response for a natural gas leak event. The pipeline failed during an operating pressure increase on a

[11] From presentation of Dr. Mures Zarea, Gas Facilities Development Manager, Gaz de France R&D Division and Chairman EPRG Design Committee to Pipeline and Hazardous Material Safety Administration (PHMSA) Mechanical Damage Technical Workshop public meeting in Houston, Texas, February 28 through March 1, 2006. Presentation can be found at web site: http://primis.phmsa.dot.gov/rd/mtgs/022806/17_RemarksZarea.pdf

section of pipeline that had been severally damaged several weeks earlier by construction work (delayed third party damage failure). The pipeline operator had been notified of the work project and had periodically monitored activity through various phases. The release started as a gas leak but transitioned to a rupture, catching many victims in the high heat flux impact zone.[12] The Ghislenghien event clearly illustrates what can happen, even to first response personnel unfortunately caught in the zone, especially the very high heat flux rupture pipeline failure early ignition fireball/jet-fire event.

V. Potential Impact Zone Considerations

As in most engineering challenges, there is usually more than one approach in addressing a particular problem. For large diameter high-pressure gas transmission pipelines that can generate extremely large potential impact zones upon rupture, Accufacts prefers the scientific process described in the previous section. This process is also more representative of what actually occurs in a gas pipeline rupture and is used by more prudent pipeline operators. As a result of the mass flow suggested in Figure 1, an example of a heat flux versus distance plot for the pipeline can be developed that should be similar in format to Figure 3.

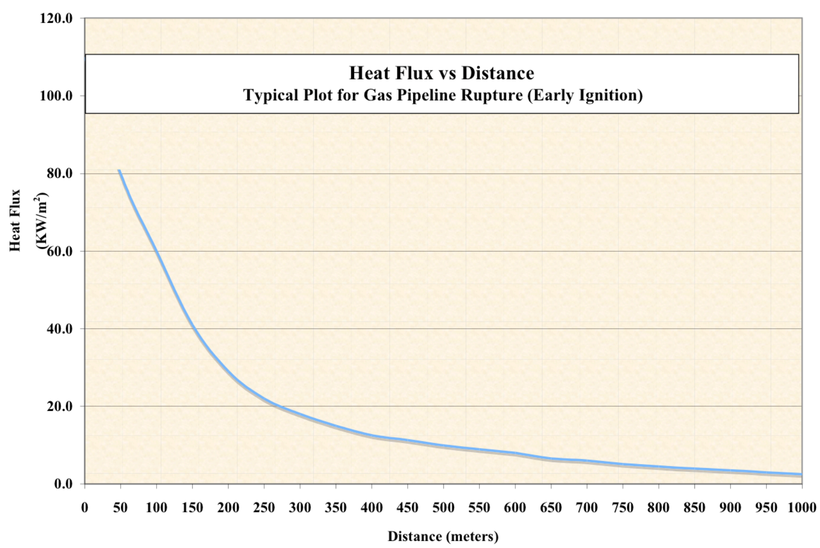

Figure 3: Example of a Heat Flux versus Distance Plot - Gas Pipeline Rupture Jet Fire

Depending on which values are utilized for certain critical variables (e.g., combustion efficiency, emissivity, heat of combustion, etc.), there can be variation in the heat flux curves. Usually instantaneous ignition is assumed for large diameter high-pressure gas pipelines, but delayed ignition sensitivity analysis lines can also be drawn (i.e., ignition at t = 30 sec, 60 sec, or depending on the system dynamics, a boundary condition of either t = 5 or 10 minutes). Usually, if a pipeline rupture has not ignited by ten minutes, the odds

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[12] Ghislenghien is most unusual in that the transmission pipeline failure released gas first as a leak for many minutes before transitioning into a rupture failure.

are good that ignition will not take place. In pipeline vernacular, a pipeline rupture that has not ignited within ten minutes is called "lucky."

The Risk Analysis from the Saint John Fire Department establishes three zones: a 300 meter "hot zone," a 300 to 800 meter "warm zone," and an 800 plus meter "cold zone." The Fire Department Risk Analysis uses additional information from the pipeline Application/Bercha QRA to define the hot zone outer boundary from a flash fire to be 170 KW/m^2 and the warm zone outermost heat flux boundary as 37.5 KW/m^2.

To properly evaluate the proposed pipeline route through the city of Saint John, the pipeline Applicant needs to develop and provide an early ignition pipeline rupture heat flux versus distance curve similar in format to that depicted in Figure 3 that can be publicly reviewed and defended.

Figure 4 is an exhibit utilized in the Accufacts report on the proposed Brunswick Pipeline route.[13] This figure plots the widely recognized heat flux and "time to" exposure for various thermal dosage effects on people and wooden structures. For those more familiar with high heat flux impacts, the series of curves are derived from the often cited Hynes (1983) as well as Bilo & Kinsman (1997) correlations presented in graphic form. The orange dash lines represent arbitrary heat flux values reported in the pipeline Application/Bercha QRA for reference.

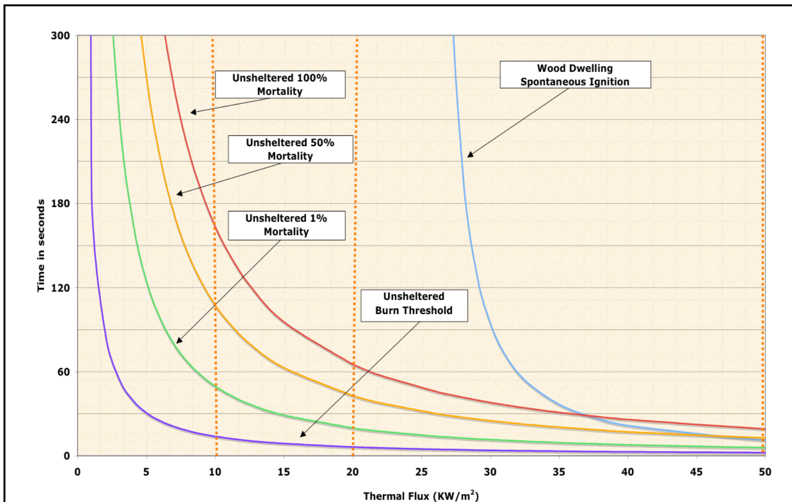

Figure 4: "Time To" for Various Thermal Fluxes on People and Wooden Structures

From these series of curves it is readily evident that high heat flux and unsheltered survivability is measured in seconds. Figure 3 and 4 curves also indicate that the 300-meter hot zone boundary limit suggested in the Fire Department Risk Analysis report is not large enough for an urban setting, and that much of the warm zone is also inappropriate for a new pipeline established in a sensitive receptor area in

300 meters is not an appropriate safety zone for this pipeline if ruptured, given the high heat flux potential/low survivability associated with rupture failure.

[13] Richard B. Kuprewicz, "An Independent Analysis of the Proposed Brunswick Pipeline Routes in Saint John, New Brunswick," September 16, 2006, page 19.

the event of a rupture. One of the critical variables concerns the acceptable boundary heat flux limit to help define the true potential impact zone in the event of a rupture. This issue is discussed in the next section.

VI. What Heat Flux Limits Should Define the Potential Impact Zone?

Once mass release over time and heat flux versus distance plots similar to Figures 2 and 3 have been developed for a particular pipeline segment in a sensitive area, agreement of an acceptable, survivable heat flux limit will enable an operator to develop and explain a rational potential impact zone for a particular pipeline route. An appropriate heat flux value should be agreed to that realistically represents the higher probability of survivability for the uniquely high heat fluxes that would be associated for this pipeline. As a point of reference for fixed non-pipeline facilities, fence boundary thermal flux limits are usually set at a maximum of 5 KW/m^2 or lower for new plants in many countries. This author is not suggesting such a limit for pipelines, but agreement to a rational thermal survivability limit is needed. Ironically, transmission pipelines carry much more potential to rapidly release hydrocarbon inventory and are capable of much higher heat fluxes than most fixed facilities (i.e., refineries, chemical plants, land based LNG facilities).

As can be seen from Figure 4, it is the heat flux ranges between 10 and 20 KW/m^2 that raise the most uncertainty about survivability that can drive proper sizing of large potential impact zones in highly sensitive areas. In our previous report on this pipeline, we cautioned the foolishness of taking credit that panicked individuals will run away from the high heat flux fire.[14] Those who make such statements have, in all probability, never been in a hydrocarbon fed high heat flux event. Unfortunately, none of the figures in this report should be taken as an absolute certainty given the wide variation of factors that can introduce considerable doubt during an emergency. It is the pipeline Applicant's responsibility to provide and defend these determinations using the processes defined in this paper. Prudence would counsel that one err on the side of caution which leads to a lower heat flux limit and larger potential impact zone in sensitive areas such as cities. Assuming that rupture failure will never occur is most unwise, if not reckless.

> The pipeline's Application/Bercha QRA analysis, also identified in Accufacts' earlier independent analysis, supplied information indicating that a 20 KW/m^2 isopleth was on the order of 500 to 600 meters from the pipeline.

If one were to determine that 10 KW/m^2 was a reasonable upper limit to define a potential impact area, Figure 3 would suggest a potential impact radius of 500 meters, a number well beyond 300 meters. The pipeline's Application/Bercha

[14] Ibid., page 20.

QRA's own studies indicate 20 KW/m^2 distances well beyond 500 meters.[15] This underscores our previous observation that it is the pipeline Applicant's responsibility to develop and defend a heat flux versus distance plot capturing early ignition that is so important to large diameter high-pressure pipeline routing considerations.

Once a rational heat flux limit has been determined and an appropriate scientifically determined potential impact radius defined utilizing this value, a sweep analysis should be completed, similar to that performed in the Fire Department Risk Analysis, to identify possible sensitive receptors within the zone that cannot tolerate the higher heat flux closer to the pipeline (e.g. fireball). Many pipeline applicants will develop a series of concentric heat flux lines (i.e., isopleths) paralleling aerial maps of the proposed pipeline route to help identify such sensitive receptors, rather then utilize the one flux catches all approach. From this author's perspective, the Fire Department was attempting a similar phased flux approach but their heat flux values are not defendable. Based on our extensive experience and background with very high heat flux hydrocarbon events, Accufacts believes the Fire Department Risk Analysis overstates survivability in the warm zone.

VII. Conclusions

A reading of this report should provide additional clear perspective and improve understanding as to the following Accufacts' findings and conclusions:

1. Emergency Response Planning should never be utilized to credit against the risks associated with pipeline rupture events. No matter how effective the ERP, response can not be fast enough to save those most at risk in the extreme heat flux zones associated with the most likely early ignition gas release scenarios.

2. Further detail from the pipeline Applicant is warranted to support understanding of the rupture mass release over time curve for the pipeline segments within the city of Saint John. The specific pipeline capacity throughput that defines this curve should be clearly stated.

3. Remote valve spacing can reduce total blowdown timing following a rupture to permit first responders to enter an affected area earlier, but notification, response and valve closure dynamics do not prevent the very high heat flux releases associated with gas transmission pipeline rupture and high casualty potential.

4. Remote valve placement cannot compensate for poor pipeline route selection in areas that can place sensitive receptors in a potential impact zone at risk.

[15] Application to the National Energy Board, Bercha Group, "Quantitative Risk Analysis of the Brunswick Natural Gas Pipeline – Final Report," February 14, 2006, Appendix A5, Table 4.3.

5. Proper heat flux versus distance plots or curves are critical to performing a prudent and thorough new pipeline route selection analysis, including a QRA when appropriate.

6. Agreement on an acceptable heat flux limit (i.e., KW/m^2) that the public can understand and accept is critical. No such value currently exists for pipelines in safety regulation, though values have been long established for fixed site non-linear infrastructure (such as refineries) in many countries.

7. A 300 meter potential impact zone is inappropriate for this particular pipeline through the city of Saint John. This report indicates that survivability in most of the RA defined warm zone during a pipeline rupture is overstated.

8. An aerial map indicating a series of heat flux lines (isopleths) paralleling a proposed pipeline route should prove helpful in verifying that sensitive receptors are not at risk, in either the fireball or the much longer jet-fire phase of a pipeline rupture.

9. Accufacts fully supports ERP efforts to insure adequate first responder resources, training, equipment, and communication links are in place if needed. ERP will not, however, compensate for unwise placement of high-pressure large diameter gas transmission pipelines.

VIII. Acronyms/Abbreviations

ACV – Automatic Closure Valve

ERP – Emergency Response Plan or Planning

EPRG – European Pipeline Research Group

FBE – Fusion Bonded Epoxy

KW/m^2 - Kilowatts per square meter, a measure of heat flux

MISHAP/PIPERS – U.K. Health and Safety Executive pipeline hazard assessment programs

NTSB – U.S. National Transportation Safety Board

PHMSA – Pipeline and Hazardous Material Safety Administration (reorganized U.S. Office of Pipeline Safety)

QRA – Quantitative Risk Analysis

RA – City of Saint John Fire Department Risk Analysis

SCADA – Supervisory Control and Data Acquisition (central control computer)

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