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Hazardous measures: an interpretive textual analysis of quantitative sensemaking during crises[1]

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Summary The current paper presents a computer-supported approach to the interpretive analysis of organizational texts and documents. Computer-supported interpretive textual analysis, as presented here, is a qualitative research approach which seeks to provide insights into members' meanings and interpretations. It uses four analytical processes: theoretical sampling, computer software supported text analysis, expansion analysis, and producing textual statistics. Interpretive textual analysis contrasts with quantitative content analysis methods which compose variables from qualitative data and use these variables to test existent theories using inferential statistics. The present paper uses computer supported textual analysis to investigate quantitative sensemaking during a public inquiry into a well blow-out involving hydrogen sulphide gas. I address three research questions relevant to crisis sensemaking. First, what quantitative practices and terms were used in sensemaking about the crisis, and how were these used? Second, how were quantitative practices relevant to the management of risks and hazards? And third, how did sensemaking vary among stakeholder groups, and what were the implications of the variations for organizational action? The results and findings from the computer-supported textual analysis show that quantitative practices and terms played an important role in inquiry sensemaking. The two theoretically meaningful groups involved in the incident used different vocabularies and logics for sensemaking. The government group used a 'step logic' to emphasize formal steps in the management of the hazard. This required the precise measurement of the hazards as a basis for initiating-rule governed actions to control the hazards. In contrast, the operator company used a logic of local safeguarding to interpret the hazards and measurements of the hazards. The paper concludes by discussing the general methodological and theoretical implications which interpretive textual analysis has for studies of sensemaking in organizational behavior research. © 1997 John Wiley & Sons, Ltd.

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Introduction

Interpretive research seeks to represent and understand members' meanings and discourse, two objectives which are increasingly important in organizational inquiry. Interpretive understanding is accomplished by linking members' meanings-in-use to elements of social context and to second order concepts of social science (Schutz, 1973). Interpretive research thus often uses qualitative, textual data as a source of information. And it applies qualitative data analysis techniques (Lee, 1991) to understand the meaning of qualitative data and texts (Kelle, 1995, p. 3).

The current paper outlines important features of a computer supported approach to interpretive textual analysis. In general, computer-supported interpretive analysis involves a complex, iterative process which relies on researchers' interpretations, induction and conceptual creativity (Kelle, 1995, p. 14). The current paper demonstrates how interpretive textual analysis can advance qualitative, interpretive research on organizations (Gephart, 1993; Kelle, 1995; Seidel and Kelle, 1995, p. 58; Gephart and Pitter, 1995), and how it can be used to analyze forms of data such as organizational conversations, discourses and documents which are difficult to analyze with other approaches (Gephart, 1993; Ford and Ford, 1995). The paper also indicates how interpretive textual analysis differs from the quantitative methods of positivist organizational science which are concerned with measuring, predicting and controlling objective features of the empirical world (Lee, 1991; Pawson, 1988).

Computer supported interpretive textual analysis has received limited attention in previous organizational behavior research. Thus I use organizational sensemaking related to crises and hazards (Weick, 1990, 1993, 1995; Gephart, 1993; Gephart and Pitter, 1993, 1995) as an example of an area where computer-supported interpretive textual analysis can contribute to organizational behavior research. The paper provides insights into crisis sensemaking in organizations by investigating the quantification and measurement practices of organizational members (Gephart, 1988a) which emerged during a public inquiry, where organizational members produced and interpreted quantitative data concerning a major organizational crisis.

The contributions of the paper are accomplished as follows. First, I discuss computer-supported quantitative content analysis and contrast this approach with the features of interpretive textual analysis used in the present paper. Then, I briefly review research on sensemaking in crises and hazards. This review clarifies the nature of quantitative sensemaking and reveals that quantitative sensemaking has received only limited previous attention in the literature. I then use the literature to pose three research questions addressed in the current paper. The first question is what quantitative practices and terms were used by members, and how? The second question is how were quantitative practices and terms used in the management of risks and hazards? And third, what variations in sensemaking were evidenced by different stakeholders, and what were the action implications of these variations in sensemaking? Next, I discuss details of the textual analysis of public inquiry discourse concerning a major industrial accident. The results and findings emerging from the computer-aided interpretive textual analysis are presented and discussed. The paper concludes by discussing how the present approach contributes to the methodological literature on computer-aided textual analysis, and how the approach provides findings which contribute to research on quantitative sensemaking in organizations.

Computer-Aided Qualitative Data Analysis

The computer-aided analysis of qualitative data can involve either quantitative analysis of qualitative data or qualitative analysis of qualitative data, or some combination of these processes (Wolfe, Gephart and Johnson, 1993; Kelle, 1995). In computer supported *quantitative content analysis*, computer software is used to automatically code and/or classify data in texts, and to count the codes or categories which are evidenced in the text (Wolfe, Gephart and Johnson, 1993). The classified and counted data are used to compose operational indicators of variables. The hypothesized relationships among the variables are then tested using methods of logical empiricism including inferential statistics (Lee, 1991). This approach is generally oriented to theory testing or confirmation research using large, random samples. For example, Kabanoff and Holt (1996) used computer-supported quantitative content analysis to test a theory of organizational values. They specified hypotheses related to the presence of certain value structures in Australian organizations, and the changes in these value structures over time (Kabanoff and Holt, 1996, pp. 206–207). These values were operationalized by assuming that the frequency of occurrence of certain 'key' words directly represents the strength of specific values. Three sources were used to develop a 'content dictionary' of key words representing each of the value categories of interest. Then, computer-aided text analysis (hereafter, CATA) software was applied to 'score' the organizational documents in terms of the observed values (Kabanoff and Holt, 1996, p. 209). Essentially, CATA software was used to identify sentences containing the key words, to count the key words representing each value category, and to generate a quantitative measure of each value category for each organization. Chi-square coefficients and F values for correlations were used to test the hypotheses posed in the study.

Interpretive textual analysis uses a qualitative approach to qualitative data analysis (Kelle, 1995) which differs significantly from quantitative content analysis. The goals of qualitative, interpretive research are understanding the meaning of the text for social actors and then developing and elaborating theory. The theory which is produced incorporates or subsumes members' meanings (Kelle, 1995). Interpretive textual analysis seeks to develop or recover themes, meanings and patterns in textual data; to provide 'thick' interpretations which display how concepts are operative in the data; and to ground theory in data in an ongoing or iterative process of analysis (Glaser and Strauss, 1967; Gephart, 1993; Gephart and Pitter, 1995). Computer-supported interpretive textual analysis uses the computer to support these qualitative analysis tasks. The analysis process is enacted through the interrelated methods of theoretical sampling, computer software-supported text analysis, expansion analysis, and producing text based descriptive statistics.

Theoretical sampling uses emerging theory and insights to establish 'analytic grounds' (Strauss, 1987, p. 36) that direct an iterative data collection and analysis process. Theoretical sampling directs attention to theoretically meaningful groups and important segments of data including key words which represent theoretical features of interest. Computer software-supported textual analysis can support mechanical and clerical tasks related to coding and retrieval, theoretical sampling and theory development (Richards and Richards, 1994; Tesch, 1991; Sibert and Shelly, 1995; Wolfe *et al.*, 1993). Specialized software can be used to recover all theoretically meaningful uses of key words, phrases or terms from the database for theoretically important categories of actors or subjects included in the sample. This provides a computer-supported basis for theoretical sampling which can be used in the constant comparative analysis process basic to grounded theory development (Glaser and Strauss, 1967; Gephart, 1993). Essentially, text analysis software disaggregates (Gephart, 1993) or decontextualizes (Dey, 1995, p. 102) segments of the text, and exhaustively recovers all textual depictions of phenomena of interest. In the process, computer software also recontextualizes data (Dey, 1995) by reorganizing data in terms of similar themes, subjects or groups. The retrieved textual data segments can be used to compose textual exhibits and tables which summarize and display the theoretically meaningful data slices which have been sampled.

The textual data displays can then be analyzed using expansion analysis (Cicourel, 1980; Fairclough, 1992). Expansion analysis is a form of fine grained hermeneutic analysis which involves writing an interpretation of data segments to show how contextual features and theoretical concepts operate in the data displays or representations. Expansion analyses often include line by line interpretations of data, and use line numbers to link interpretations to data. This recontextualizes the data by connecting theoretical concepts and terms to members' naturally-occurring discourse, and to the interpretive contexts linked to the data (Dey, 1995, p. 103). It also provides a basis for the comparative analysis of the data. For example, the retrieved data can be organized so as to provide displays which contain all data segments representing similar concepts or themes, or all statements by a given theoretically meaningful group. The interpretation of the displays can proceed by addressing 'within category' similarities in text segments that represent similar concepts or groups, and 'between category' differences in text segments representing different concepts and/or groups (Sibert and Shelly, 1995; Gephart, 1993; Gephart and Pitter, 1995). The expansion analysis links the categories and themes used to organize and retrieve data to the substantive features of the data and to the empirical, conceptual and theoretical concepts and contexts used to interpret the data. In this way, computer-supported interpretive textual analysis can support fine grained interpretive or expansion analysis (Lonkilla, 1995) of small scale, selectively chosen textual displays (Seidel and Kelle, 1995, p. 58).

Computer software also supports expansion analysis by providing a series of linked textual displays wherein key words can be viewed in their original textual contexts, and this context can be varied in terms of contextual information displayed. Possible displays include: an index display listing key words; a key word in context display which shows the words in the sentences and paragraphs in which they appear; and a display which contains the entire original text with the key words highlighted. In addition, recontextualization is supported by providing contextual information on the sources of data, persons speaking in the data, time, and other factual information of interest. And data segments can also be linked to other sources and forms of data which can be rapidly retrieved and inspected. Computer-supported interpretive textual analysis can then be used to link the results of detailed hermeneutic analysis of small samples to broader, more comprehensive and exhaustive textual samples (Gephart, 1993; Gephart and Pitter, 1995).

Computer-supported interpretive textual analysis also offers a strategy for using the indexing and retrieval capabilities of computer software to construct text-based descriptive statistics which establish linkages (Fielding and Fielding, 1986) between qualitative and quantitative data (Gephart, 1988a; Kelle, 1995; Kuckartz, 1995; Roller, Mathes and Eckert, 1995). This linkage strategy differs from previously proposed integration strategies (Fielding and Fielding, 1986; Kelle, 1995; Kuckartz, 1995; Roller *et al.*, 1995) which rely on coding or classification of cases (Kuckartz, 1995; Roller *et al.*, 1995) as a means of qualifying qualitative aspects of text. The development of interpretive textual measures or 'quasi-statistics' is in its infancy and there is some debate concerning the desirability of integrating qualitative and quantitative data in interpretive research (Tallerico, 1992), hence the present discussion is provisional. Interpretive textual measures have heuristic value and should be viewed as descriptive measures which highlight the strength of relationships observed in the sample (Kuckartz, 1995, p. 166). They offer tools for reflecting on data (Tallerico, 1992) which help demonstrate linkages among actors' first order concepts and the second order scientific constructs or concepts of organizational behavior. They are concerned to support discovery not to demonstrate statistical generalizability since they are the result of purposeful and not random sampling (Kelle, 1995, p. 23). Such measures must be carefully linked to subjects' own methods of ordering the world (Hesse-Biber and Dupuis, 1995, p. 135) so that they reflect meaningful linkages based on distances among concepts or words in the document (Huber, 1995, p. 145). They can be created through integrative triangulation whereby the textual data analyzed in expansion analysis are subjected to a second or quantitative analysis (Prein and Kuckartz, 1995, p. 152).

Collocation statistics based on key words provide one possible basis for developing textual measures. Collocation statistics provide a quantitative measure of the likelihood that the co-occurrence of selected key words in a text segment differs from (is more likely than) the likelihood of the words co-occurring in the overall text. The key words are important elements of cultural grammars which reflect native categories of thought and yield insights into cultural dynamics and logics (Colby, Kennedy and Milanesi, 1992, pp. 373, 377). The key words can be theoretically surfaced, justified by detailed analysis of textual displays, and used to link subjects' and researchers' concepts. Following this reasoning, collocation statistics can be used to provide evidence of 'meaningful linkages' among key words in subjects' discourse as well as to establish linkages among these key words and the concepts of organizational behavior.

Computer-supported interpretive textual analysis is exemplified by an investigation of crisis sensemaking related to a pipeline leak (Gephart, 1993). This study used interpretive textual analysis to store and selectively retrieve important textual passages from transcripts of discourse at a public inquiry into the accident. Theoretical sampling was used to identify key groups and issues in the accident inquiry and to ascertain the key words which members used to represent issues related to risk, blame, authority, responsibility, and other themes of theoretical interest. Textual exhibits were composed for detailed passages concerning important issues in the data. Textual exhibits provide contextual information, link the analysis closely to raw data, and illustrate the richness and complexity of the data (Gephart, 1993, p. 1483). Then, computer software developed for literary text analysis was used to produce textual tables which organized the passages in terms of similar concepts for the important groups, based on key word occurrences. Thus the software provided data displays which allowed comparisons across different groups and concepts of interest. The textual displays were then interpreted using an expansion or fine grained hermeneutic analysis which surfaced insights into the phenomena of interest. The expansion analysis of the textual tables provided for comprehensive analysis of all occurrences of key words and themes in the textual data (Gephart, 1993, p. 1484). The tables extended the range of data and issues addressed in analysis; provided for broad-based comparative analysis; enhanced the density of theoretical samples; and substantiated insights from the analysis of textual exhibits. The analysis demonstrated the different sensemaking resources used by each group and how this sensemaking had consequences for organizational actions.

In the current paper, I show how the four elements of computer-supported interpretive textual analysis—theoretical sampling, computer software-supported textual analysis, expansion analysis, and producing textual statistics and meaningful linkages—can be used to investigate quantitative sensemaking concerning organizational hazards.

Sensemaking

The conceptual focus of the present paper is sensemaking, the activity or process of generating a social world and then interpreting the world (Weick, 1995, p. 13). Sense is generated by words combined into sentences in conversation which communicate aspects of experience (Weick, 1995, p. 106). Sensemaking includes sensing and constructing features of the world which then become available to perception (Weick, 1995, p. 14). Sensemaking thus addresses the invention process which precedes interpretation, as well as the interpretation process itself. Interpretation arises through the provision of explanations and accounts of the sensed features or phenomena (Weick, 1995, p. 7). Sensemaking is foundational to organizational behaviour (Weick, 1995) because sensemaking creates and constitutes the organization and its structure as a set of assumedly shared meanings (Bittner, 1965; Gephart, 1978). If sensemaking is disrupted, the organization collapses, unravels or disintegrates (Weick, 1993, p. 628).

Sensemaking is driven by plausibility, not accuracy (Weick, 1995, pp. 55–61). Accuracy refers to the correctness of perception (Weick, 1995) and implies that one has a true, exact and precise perception. Scientifically, accuracy refers to agreement of an observed measure with a standard value for that measure (Random House, 1968, p. 10). In contrast, plausibility is based on the reasonableness of an interpretation and its fit with some known facts (Isenberg in Weick, 1995, p. 56). The reasoning may be based on incomplete information and may be incorrect, but the reasoning produces a 'good story' (Weick, 1995, p. 61). Plausible sensemaking is thus the provision of acceptable and credible accounts which explain phenomena and energize action (Weick, 1995, p. 61).

An important feature of sensemaking is the use of sensemaking practices (Garfinkel, 1967; Leiter, 1980; Gephart, 1993). Sensemaking practices are activities which create a world of sensible objects and processes. Sensemaking practices are manifest in language, text and discourse including conversations, vocabularies, utterances, and documents. Sensemaking practices provide interpretations of this world as well as offering meaningful bases for actions. These practices often refer to implicit assumptions and interpretive schemes of social actors and groups including tacit logics.

For example, the use of normal forms is a widely researched sensemaking practice evident in accounts and explanations (Gephart, 1993). This practice is used when members recognize 'normal' and abnormal cues or features of their environment and interpret these features as indicators of normal and abnormal form objects and processes in their environment (Gephart, 1993, p. 1470, following Garfinkel (1967) and Leiter (1980)). An example of the use of such normal forms in conjunction with tacit assumptions and logics is provided by a study of multi-piece truck wheel hub accidents. Baccus (1986) found that top-down safety logics dominate the discourse of regulatory agencies concerned to make sense of these accidents. Top-down logic addressed the logical conditions necessary to prevent accidents of known kinds. Regulators discussed and sought formally prescribed practices or tools which are normally present in a setting but which were omitted in a given accident. Regulators interpreted troubles by presuming the existence of formal steps or sequences of actions which could be undertaken to prevent problems. They sought to determine problems which arose at each 'step' in the work processes associated with a given accident. These steps were thus viewed as normal form practices which produced accidents when they were disrupted. Regulatory discourse thus used tacit assumptions and an implied 'top-down' safety logic to interpret the accidents. This logic was reflected in regulatory discourse through the use of words which focused on procedural issues, for example the frequent use of the word 'steps'. In contrast, situated logic was used by workers and operating personnel. Situated logic emphasized goal attainment and task accomplishment in the context of an unpredictable work setting. Situated logic took the form of a personal safeguarding logic which allowed emergent and *ad hoc* procedures and practices to substitute for formal safety devices. Situational logic is driven by the logic of object use wherein demands for action seem to emerge from the object itself and not from some extra-situational logic. In both logics, the focus was on accomplishing specific goals in specific settings. The emphasis during discourse was on local practices, informal recipes for action, and situational particulars related to task accomplishment.

Quantitative sensemaking and the management of organizational hazards

Research on sensemaking in organizations has often been directed at the interpretation of unusual events which disrupt sensemaking (Weick, 1995). Topics have included risks and hazards (Gephart and Pitter, 1993), organizational accidents and disasters (Weick, 1988, 1990, 1993; Gephart, 1993; Gephart and Pitter, 1995), the avoidance of disasters in high reliability organizations (Weick and Roberts, 1993) and organizational actions in high hazard industries such as nuclear power generation facilities (Carroll, 1995, pp. 175, 192). Sensemaking is consequential for organizational actions. Yet there are significant limits to our knowledge of crisis sensemaking in organizations (Perin, 1995, p. 157). Thus an important conceptual purpose of the present paper is to develop additional insights into organizational sensemaking about hazards.

My concern in the present paper is the important and relatively neglected issue of quantitative sensemaking as undertaken by organizational members. This 'native quantification' employs quantitative terms and quantification practices during sensemaking. Quantitative representations express quantities and relations which are subject to mathematical operations. They refer to measurable features of phenomena. Quantitative practices can thus be defined as activities which represent phenomena using numerals and descriptors of quantities. The focus of quantitative practices is the representation of quantities and magnitudes: the mass, volume, number, size, concentration or amounts of some phenomenon. These quantitative operations occur at both the common sense and scientific levels of analysis.

The general importance of quantitative sensemaking has been established through investigations of how professionals use numbers and statistics in technical reasoning (Bogdan and Ksander, 1980; Gephart, 1988a). Starbuck and Mezias (1996, p. 103) note that organizational research instruments which pose 'questions about facts usually ask for quantitative answers'. Rifkin (1994) found numerical data were more highly regarded than 'mere observations' (Rifkin, 1994, p. 75) during Water Board hearings. Use of technical terms including numbers and quantitative representations evidenced competence at the hearings, helped make the experts more relevant to the hearings (Rifkin, 1994, p. 89), legitimated the expert status of witnesses and thus was related to success in debates on technical issues. In contrast, descriptive and non-quantitative statements were more likely to make witnesses vulnerable to criticism and debate than were quantitative observations. Dow (1994) has argued that quantitative data and technical jargon enhance witness credibility in hearings and formal proceedings. And Brent (1994) has stated that abstract data are given greater regard than other observations (p. 113) when discussing technical facts. Indeed, the professionally appropriate uses of numbers and quantification practices is basic to technical competence and legitimacy in many organizational and occupational cultures (Gephart, 1988a) including engineering (Carroll, 1995, p. 185).

Quantification is important in sensemaking about accident causes. In the case of a gas well accident, unusual odours and other signs were interpreted as evidence of an uncontrolled flow of gas. Yet precise quantitative measures were needed to interpret these cues as 'facts' which established the nature of the problem (e.g. toxic gas leak) and the action required, and to direct the actions taken (Gephart, 1988b). Quantitative measures thus acted to validate and socially construct (Berger and Luckmann, 1966) the event as a real and critical problem of a particular nature. Thus quantitative sensemaking plays an important role in determining the nature, causes and consequences of accidents (Gephart, 1993, p. 1474). We can thus expect quantitative sensemaking to play an important role in organizational crisis sensemaking. This should be particularly evident in expert sensemaking during the public inquiry stage of an accident (Gephart and Pitter, 1993, 1995) given that inquiries are important occasions for the professional interpretation of accident causes. One can thus use textual data representing discourse at a public inquiry as a basis for illustrating how interpretive textual analysis can be used to uncover important features of quantitative sensemaking about organizational risks and hazards.

Research questions

The current paper uses computer-supported interpretive textual analysis to address the following questions. First, what quantitative practices and terms were used in sensemaking about the organizational crisis, and how were these used? Second, how were quantitative practices and measures (e.g. numerals) related to the management of risks and hazards? Third, what variations in quantitative sensemaking occurred across different crisis stakeholder groups, and what were the action implications of these variations?

Methods

The 1977–1978 Lodgepole 'sour gas well' blow-out and inquiry

The focus of the paper is the Government of Alberta Energy Resources Conservation Board Public Inquiry into an uncontrolled flow of hydrogen sulphide ('sour') gas from an exploratory well—Amoco 7–10—drilled near Lodgepole Alberta, by Amoco Canada Petroleum Company Ltd. Hydrogen sulphide gas (H_2S) is a naturally-occurring substance extracted from deep subsurface locations. It is highly hazardous and is considered second only to cyanide as a toxic killer (Smith, no date).[2] The uncontrolled flow or 'blow-out' commenced at approximately 16.30 hours on 6 December 1977, at a time when the air temperature was $-35°C$. During the uncontrolled flow, at least four persons were hospitalized and treated for H_2S exposure. H_2S was detected over an area of several thousand square kilometres and hundreds of thousands of residents were exposed to low levels of H_2S. Concentrations of 30 p.p.m. of H_2S were recorded in air samples some 1.5 km distant from the well head. Several plans for regaining control of the well were unsuccessful, and the international well control expert Red Adair was commissioned to assist in well control efforts. Control of the flow was regained on 2 January 1978 at approximately 14.10 hours, after flowing uncontrolled for 28 days. The release from the uncontrolled flow was estimated at 16×10^6 m^3 of gas with an H_2S content of 25 per cent in later documents (Alberta Energy Resources Conservation Board, 1984), although as this paper indicates, such estimates are potentially inexact.[3]

[2] Industrial working conditions permit an atmosphere of 10 parts per million (p.p.m.) of H_2S. Concentrations of 50 to 250 p.p.m. can cause olfactory paralysis; pulmonary edema and imminent threat to life can occur when concentrations reach 300 to 500 p.p.m., with unconsciousness occurring at concentrations of 700 p.p.m. Brain damage and instantaneous unconsciousness occur at 1000 p.p.m., and death is imminent once a victim is unconscious.

[3] A similar H_2S flow or incident occurred several years later. This incident, termed the Lodgepole 1982 blow-out, was more serious in nature and has been partially addressed in a previous paper (Gephart, 1988b).

At the time of the incident, the focal company Amoco Canada Petroleum Company, Ltd. was a wholly owned subsidiary of Standard Oil Company (Indiana), headquartered in Calgary, Canada. Amoco Canada has extensive experience in the exploration and production of oil and gas. In 1977–1978 Amoco Canada was the leading Canadian producer of crude oil, natural gas liquids, natural gas, and sulphur.

The official inquiry was conducted by the Alberta Energy Resources Conservation Board (hereafter the ERCB), which at the time of the incident was a Government of Alberta corporation responsible for regulating all oil, gas and pipeline operations within Alberta. The inquiry was held on 22 and 23 February 1978 in the Royal Canadian Legion Hall, Drayton Valley, Alberta. The inquiry was conducted by a board composed of three members, including the chair. Amoco Canada personnel appeared at the inquiry, as did representatives of the drilling contractor, other industry companies and relevant Government of Alberta agencies. The Inquiry Board had authority to inquire or report on any matters under its purview, and to recommend any measures or actions it deemed necessary to protect public interests related to any aspect of energy production, transportation or use. This authority was legally provided the Alberta Energy Resources Conservation Act, which also provided the Board with the authority to compel persons to appear and provide evidence at a hearing. Public inquiries provide 'an open public testing of technical, environmental, social and economic evidence' related to energy development (Energy Alberta, 1986, p. 36) and were a mechanism the Board used to inquire into 'critical issues, or especially significant energy-related accidents in order to provide the public with a full report' (Energy Alberta, 1986, p. 36).

Data and Data Bases

The data used in this study include the 217-page official proceedings of the ERCB Inquiry into the accident (Alberta Energy Resources Conservation Board, 1978a) and the 16-page ERCB final report on the incident (Alberta Energy Resources Conservation Board, 1978b).[4] Two text-oriented data bases were constructed for the documents used in the study: (1) a word processor file containing the text of the two key documents, and (2) a T.A.C.T. (Textual Analysis Computing Tools) textual data base containing these key documents. TACT (Bradley, 1988, 1990) is a textual retrieval program useful in computer-aided textual analysis (Wolfe *et al.*, 1993).[5] Textual analysis using TACT is driven by key word selections. The researcher can select one or more key words from a list of all words in the document, and then recover the actual documentary text containing the key words. Data retrieval can be organized in terms of structural codes inserted into the text by the researchers. The following codes were used in the current text data

[4] Prior to the current data analysis, a case description of the present incident was prepared, summarizing the issues and events in the accident (Engen and Gephart, 1986).

[5] It was developed for computing in the humanities hence it is oriented to representing and recovering textual features—words, word patterns, their locations and their frequency—representing the organization and substance of written documents such as classic literature (e.g. Shakespeare). This makes TACT highly appropriate for analyzing organizational documents which are structured as literary texts, with chapters, characters, and other common literary organizing features, and for representing inquiry documents which are structured in terms of sessions and speakers, much like the script of a play. Overviews of TACT are found in Gephart (1993) and Gephart and Pitter (1995) and the user manual (Bradley, 1988, 1990). The current research used TACT version 1.2. An upgraded version which incorporates previous features can be downloaded free from the following website: http://www.epas.utoronto.ca:8080/cch/tact.hmtl.

Table 1. TACT 1.2 retrieval displays

1. *Selection List*. A list of all words in the text, listed alphabetically, with the frequency of occurrence of each key word given.

2. *Index Display*. A display showing one line of text for each selected key word occurrence, with the key word highlighted. Reference information (e.g. line number of occurrence, speaker, etc.) is also displayed.

3. *Key Word in Context (KWIC) Display*. A display showing the highlighted key word in the context of an excerpt from the original text. The user can select the size of adjacent text to display. Reference field information is also displayed.

4. *The Text*. This displays the key word, highlighted, with an entire page of associated text presented. The user can scroll up and down the entire text file.

5. *The Distribution Display*. This generates a simple histogram graph depicting the distribution of selected key word occurrences in the text. The histogram can be based on any reference codes (e.g. speakers) and not simply textual location.

6. *The Collocation Display*. This display shows all the words which occur near the selected key word in the text, and it reports a Z-score which measures the significance of the co-occurrence. The Z-score is computed as follows. $Z =$ (observed frequency of collocate$-E)/SD$ where $E = P^*$ length of the mini text; $P =$ (frequency of collocate in full text)/(length of text); and $SD =$ square root (length of mini text $^*p^*(1-p)$).

base: character, date, line, organizations, page, paragraph, statement-type (question, response), time and word. TACT provides several displays, summarized in Table 1, all of which were used in the present study.

Developing a Focus

The initial stage of interpretive textual analysis involves establishing and elaborating a focus through grounded theory development and theoretical sampling. For the present paper, this focus emerged from knowledge of the crisis sensemaking literature and from general knowledge of oil, gas and pipeline accidents. Inspection of data sources was also undertaken to determine whether the data contained extensive evidence of quantitative sensemaking related to the H_2S release. I read the documents carefully. I used my knowledge of the occupational and technical vocabularies of personnel in the oil and gas industry, as well as my general knowledge of English vocabulary, to locate quantitative themes, terms and expressions in inquiry documents. I then sought to establish whether or not these themes and terms played an important role in inquiry discourse. Based on this reading of documents, I determined that subjects dealt extensively with quantitative issues in their discourse. I then generated a list of quantitative terms and expressions oriented to the quantitative features of the leak—quantity, flow, content, size, concentration, volume and number. These are key words which might be expected to occur in discourse concerning this or any uncontrolled flow from a gas well. I also constructed a list of possible descriptors of the leak itself—e.g. hydrocarbons, hydrogen sulphide, sour gas, condensate, and uncontrolled flow. Further, I posed possible key words which might be used by members to describe the actions involved in assessing the leak or flow: for example, monitoring. In general, my intent was to develop a comprehensive set of key words which were used by members to describe the leak, the size and extent of the leak, and the ways in which the leak itself was recognized, assessed and managed.

Next, I used the indexing features of the software to ascertain the frequency of occurrence of the selected quantitative key words, and to retrieve the uses of the words to examine their meanings in their documentary contexts. This further substantiated the assumption that quantitative aspects of the incident were extensively thematized in inquiry discussions. For example, I was able to retrieve statements concerning the height of the flowing plume, the concentrations of gas emissions, the numbered sections of land which describe the lease site, the times of various events, and the depth of drilling. This retrieval process helped focus the research process on key words which were used extensively and/or used in important ways by members. Data displays were created to display the key words in the context of the sentences, paragraphs, and whole texts where they appeared. These displays were particularly useful in understanding the important quantitative themes and terms of members. This analytical process established that the concepts of 'measures' and 'hazards' were important to participants, and were often addressed when the dimensions of size and nature (above) were discussed. This was reflected explicitly in the ERCB statement that the purpose of the inquiry was to investigate:

> '(a) the cause of the blow out; (b) the method of bringing the well under control; (c) the measures necessary to reduce the possibility of a similar occurrence; (d) the hazard to people which may have been created by the sour gas; (e) the effect upon the environment; and (f) such other matters relating to the blow-out as may be considered material'[6].

By developing and interpreting textual displays of all uses of key words, I confirmed that the term measures acquired two meanings during the inquiry testimony: (1) measures were actions taken, and (2) measures were quantitative representations of the uncontrolled flow. The flow was viewed as a hazard which could be quantitatively assessed or measured in terms of concentrations, levels and parts per million (p.p.m.) of H_2S. Using measures (actions) it could be reduced, presumably, to near zero. Hazards and measures then became the working focus of the exploratory analysis.

An expansion analysis was then developed to provide insights into how, from members' point of view, measures could be used to represent and control features of the 'hazard'. This required consideration of how the 'object' of concern—a sour gas well blow-out—became detectable and sensible during the blow-out and the subsequent inquiry. To represent the processes of detection and sensemaking, I developed textual exhibits which contain important segments of testimony wherein discussions of hazards and measures were addressed at length. Detailed, line by line expansion analysis of these exhibits provided detailed insights into sensemaking about hazards and measures, and it provided evidence of the differential sensemaking practices and meanings used by the two key stakeholder groups—the ERCB and Amoco Canada. The discussion of textual table data below addresses important quantitative themes which emerged from the data.

The analysis of the textual exhibits was supplemented by analysis of textual tables. The textual tables were composed from computer-generated indices and key word in context displays of all hazard- and measurement-related key words which occurred during the inquiry. The key words included in the tables were hazard, hazardous, hazards, measure, measured, measurement, measurements, measures, and measuring. Expansion analysis of these tables provides a comprehensive assessment of the actual meanings members have for these terms. The analysis provides insights into the role quantification practices played in sensemaking about the uncontrolled flow. The primary interpretive strategy was to review the key words and their associated textual context to insure that the retrieved words had the intended meaning. An interpretation of the data in textual tables was then prepared in a manner similar to the expansion analysis of the textual exhibits. This involved linking the different themes revealed in the separate occurrences, and then

[6] Alberta Energy Resources Conservation Board, 1978a.

relating these themes and meanings to emerging conceptual issues and insights. Next, the results of analysis of textual exhibits and textual tables were reviewed. Important variations in meaning between the two theoretically meaningful groups were further explored via reflection. The tables and analysis thus provide evidence to substantiate and elaborate the general findings developed from analysis of textual exhibits.

The next feature of the current research approach was the generation and interpretation of the collocation statistics for key word uses by each group. The collocation or co-occurrence statistic used is the Z-score which represents the possibility that the co-occurrence in a mini-text is non-random, that is, that the co-occurrence is more likely to occur in a mini-text than in the text as a whole. A mini-text is a text segment which includes a selected key word and the adjacent words. The Z-score is computed by comparing the frequency of the key words in the mini-text to an expected theoretical frequency based on occurrences of the words in the entire text or document. A higher Z-score indicates a higher association between the collocate and key word than for other words in the text as a whole (Bradley, 1990, p. 3). In this study, collocates were computed using a default setting for the range or size of the mini-text of $\pm$ five words from the key word. For current purposes, collocate Z-scores are used as an indication that the occurrence of the collocate and the key word reflect a pattern of co-occurrence. The important aspect of collocations is the ordering of words resulting from the Z-scores rather than the actual Z-score itself.[7] Interpretations of collocates are not presently guided by well-established criteria. Thus I used an informal rule that I would interpret only those collocates with Z-scores greater than 7 where the collocate occurred with a frequency of 3 or greater in the mini-text. The Z-score of 7 or greater rule was used because this appeared to be a point below which many collocates occurred only with marginal frequency (e.g. $n = 1$). The $F = 3$ rule was used to eliminate collocates with low frequencies but high Z-scores. These rules of thumb direct attention to those words which collocate most strongly with the hazards and measurement key words.

Analysis of Textual Exhibits

The discussion of textual exhibits demonstrates how diverse perceptual cues were used by subjects to establish the factuality of the sour gas blow-out as an 'objective' feature of subjects' environments. The textual exhibits are presented in the sequence in which discussion of the topics occurred during the inquiry, to reflect the chronology of account-giving at the inquiry.

Calculating dispersion

Hydrogen sulphide gas flowing from a well site disperses into the atmosphere, while condensates accumulate near the ground. Higher temperatures and air movement create greater dispersion which reduces concentrations of H_2S and condensates. Early in the inquiry, the ERCB questioned another government agency—Alberta Environment—about their ability to accurately assess the

[7] The formula used by TACT to calculate Z-scores is as follows: $Z =$ (Observed frequency of collocate $- E)/SD$ where $E = P^*$ length of the mini-text surrounding the collocate, $P =$ (frequency of collocate in full text)/(length of the text), $SD =$ Sqrt (length of the mini-text $^*p^*(1 - p)$). There is debate regarding the appropriate way to calculate Z-scores. Here, I have used the method employed by the software.

EXHIBIT ONE
Theoretical Calculations

Mr Bohme, ERCB examines Mr Schultz, Alberta Environment, p. 39

Q I guess what I was concerned with was whether or not it is
possible to use the information that you acquired throughout
the monitoring to run any kind of checks on the theoretical
calculations that you made.

A In order to make theoretical calculations of dispersions
you have to have relatively exact emission information, and
that was one of the things that we were really lacking in
terms of available information. We did not have an accurate
gas flow rate from the well blow-out, and we did not have an
accurate indication of the hydrogen sulphide levels in the
emission gas.

dispersion of the gas and hence to anticipate problematic levels (Exhibit 1). The issue of dispersion is important since concentrations of H_2S which arose during the incident created a potential health hazard for humans.

The data reveal that Alberta Environment produced imprecise dispersion calculations and estimates as a basis for action. This imprecision resulted from the lack of exact quantitative information on the flow rate from the well and from the absence of accurate information on the hydrogen sulphide levels in the gas. Normal form quantitative practices of making calculations, monitoring of the incident, and checking on the calculations were undertaken but were ineffective. An important issue in sensemaking was the production of 'theoretical calculations' which required 'exact emission information' (line 9) that was not available. Measurements based on theoretical calculations were relevant but implausible given the inexactness and uncertainty of information used in theoretical calculations. And the considerable information gathered through province-wide monitoring of the hydrogen sulphide levels was not very useful in anticipating the location of particular H_3S hazards, nor in validating calculations used to estimate hazards. Thus while the theoretically-based calculations were produced and used by Alberta Environment, the calculated dispersions were implausible. Indeed, a key issue in sensemaking here concerned the relative certainty of measures, and this led members to make an apparent distinction between 'measures' and less quantitatively certain entities such as 'theoretical calculations'.

The nature of the blow-out

A key issue for members involved in the event was interpreting the initial sensings, i.e. determining 'what is it?' (Exhibit 2). Inquiry discourse displays concern for both retrospective and prospective aspects of the process which constructed this 'it'. The incident was first sensed via olfactory perception as an odour and was interpreted as sweet gas. Later, interpretations were changed and the incident was affirmed to be an uncontrolled flow of hydrogen sulphide gas. These are discursive constructions of two normal forms of gas stated in non-technical terms: natural or sweet and sour gas. Quantification is implied since the distinction between sweet and

EXHIBIT TWO
The Nature of the Blow-Out

Mr McLarty, ERCB Examines Mr Neidermayer from Amoco, pp. 152–154

Q Gentlemen, it is my understanding that there were some media
reports when the well in fact blew out, that the well blew in
sweet. I note from the fact summary sheet, which was provided yesterday, on
page 2 you indicate that: 'At 4.45 p.m. on December
6, 1977, the well commenced flowing wet natural gas which later
turned sour'; is that the case?

A **Mr Neidermayer:** Mr McLarty, you have related the
perceptions as we understood them at the time. In fact, the
early reports were that the gas was sweet. We have people
in our organization to this point that would contend and swear
that the gas was sweet when it came out initially. Subsequent
analysis, which is not, of course, completely known, would
suggest, however, that maybe it got sour very quickly on a
blow-out, but because of the strong southeast winds, and since the
access to the drill site was from the southeast or the south,
that maybe the H_2S was being driven away from the drill site and
not detected. It is hard for me to imagine with what we now
believe to be a fairly high H_2S concentration gas that it wasn't
present very soon after the blow, but the early perceptions of
the people on site was that it was sweet gas.

Q Sir, were these early perceptions the result of
determination by odor, or were there some other efforts made to
determine whether the gas was sour or not?

A Of course, the odor is the first thing, and we have all
got a sniffer, so that is certainly the first warning. But there
were sniffer checks made as well, but presumably because of the proximity of
the man with the sniffer to the wind direction we
didn't detect the H_2S that I suspect was probably there shortly
after the blow.

Q Can you tell us, Mr Neidermayer, how soon after the blow Amoco firmly
convinced that they did have sour gas blowing out of that
well?

A I guess I cannot specifically answer that question, but the blow did occur
late in the afternoon of the 6th. The report that I got the following morning
was an indication of H_2S, so sometime in the intervening few hours it became
evident that we had H_2S.

Q I take it then, sir, that it wouldn't have been until
the morning of the 7th that Amoco were really fully prepared
to deal with what might have been or could have been a
sour gas problem?

A We were not in a commissioning phase until the
following morning so far as taking care of, in a diligent manner,

the on-site and off-site implications of H_2S, that is right.

Q I further understand, Mr Neidermayer, that the early
beliefs of Amoco were that the well was flowing at a
reasonably low rate being something less than 10 million cubic
feet a day with a reasonably low H_2S content being something less
than 5 per cent H_2S. Were those your early original beliefs?

A I wouldn't want to say that those specific numbers were our
beliefs, but the general arena you have just suggested is
correct. Again, these are all estimates, and these estimates are
visual and perceptual and could be quite significantly in error.
There isn't a lot of experience in making visual observations in what a flow
rate is. There isn't a convenient and good way when
a well is blowing to catch a sample and to determine what the H_2S
content is. But because there wasn't a lot of H_2S in the area
the feeling was that it was a relatively low percentage.

sour gas is based on the levels of concentrations of H_2S present, not the mere presence of H_2S itself. The distinction is inexact. Virtually all gas flowing from wells has some sulphur content and there is no specific level or concentration of H_2S which differentiates low sulphur content 'sweet' gas from high sulphur content 'sour' or hydrogen sulphide gas.

The certainty or plausibility of the two divergent interpretations of type of gas was a problem. Discussion addressed how the company determined the incident was a hydrogen sulphide (sour) gas blow-out, how rapidly this occurred and how this influenced responses to the event. The determination that the leak was sour gas was considered more plausible than earlier interpretations and was used retrospectively at the inquiry to question the prior actions and interpretations of members.

In response to these questions, 'perceptions' are given (line 14) as the basis for initial interpretations that sweet gas was flowing from the well. 'Subsequent analysis' (lines 17–18) generated the contradictory interpretation that the well was flowing 'sour' gas. The two different interpretations are resolved by finding good contextual reasons that the initial interpretations were flawed. Thus perceptions were possibly in error due to wind direction and the location of personnel which prevented them from detecting the sulphur odour (lines 20–21). Later contextual cues contradicted preliminary interpretations and confirmed logically if not empirically that the release was 'high H_2S concentration gas' (line 24).

Interestingly, the 'early perceptions' of a sweet gas blow-out were based on detecting the odour of the flow. These interpretations were also confirmed by actual measured evidence generated by a 'sniffer' (lines 32–33), a gas detection device which measures H_2S concentrations. Given that later information indicated the blow-out involved sour gas, the evidence from the sniffer became retrospectively equivocal and implausible. Thus after the fact, members provided good reasons for the problematic evidence, and these reasons were essentially based in the contextual problems of sensing the gas with a sniffer. The consequence of the problematic initial interpretation was that a normal form sweet (low concentration sour) gas well blow-out was incorrectly assumed by Amoco to have been occurring for some 12 hours. This interpretation of the blow-out was the basis for Amoco's apparent failure to act in a manner appropriate to a hazardous H_2S leak (lines 54+).

Amoco's beliefs that the flow was 'reasonably low rate' and 'reasonably low H_2S content' (p. 2, lines 6–7) evidence the relative uncertainty and inaccuracy of measures of H_2S. Mr Neidermayer equivocates on 'those specific numbers' (p. 2, line 9). He accepts the imprecision of the measures and the subjective and personal nature of 'estimates' and quantitative descriptors: 'these estimates are visual and perceptual and could be quite significantly in error'. Further, he addresses the problematic nature of any measurement process since there is no 'good way' to 'catch a sample and to determine what the H_2S content is' (p. 2, lines 15–16). The available means for determining the quantifiable features of the leak are general perceptions ('there wasn't a lot of H_2S in the area', line 16) and subjective experiences ('the feeling that it was a relatively low percentage', p. 2, line 17). These were used in composing, assessing, interpreting and even rejecting hard, 'objective' features and measures of the incident. In summary, definitive sensemaking involved noticing perceptually available cues, using context to interpret these, and affirming the interpretations were plausible. Measurement devices displayed quantifiable features of the incident. But the beliefs and feelings people held about the events impacted their interpretations of the event. These beliefs and feelings made the quantitative representations and measures implausible even when the quantities of phenomena were stated very precisely.

Evaluating the potential flow rate

The inability to establish the potential or actual flow rate is thematized in Exhibit 3. The uncertainty regarding measures of the blow-out is striking (lines 11–12). Convenience samples of air from pre-established monitors at other gas plants were used to induce or conjecture (line 17) that it was plausible to assert H_2S was present 'throughout the Province' (line 13). Conjecture—and not direct measures from monitoring equipment—is thus offered as the primary basis for the determination of 'a significant flow with a substantial H_2S content' (lines 18–19). The conjecture is based on holistic interpretation of disparate cues which could not be empirically substantiated (lines 19–21) until the well was brought into production. Essentially, certain

EXHIBIT THREE
Evaluating the Potential Flow Rate

Mr McLarty, ERCB examines Mr Neidermayer, Amoco, pp. 154–155

Q As I understand it, Mr Neidermayer, the potential flow rate
from this well has still not been evaluated nor has the H_2S
content in the gas been absolutely determined; is that correct?

A That is correct. When you say 'absolutely determined', we
don't know what the H_2S content of the gas is, in fact, and
we don't know what the well was flowing at. We have, however,
acknowledged the placement of H_2S throughout the Province. You
are aware that all the sour gas plants in the Province are
outfitted with static and continuous monitoring equipment. We
have attempted to see if there was an impact as a result of our
blow on these devices. As a result of that, conjecturally we now
feel that we have a significant flow with a substantial H_2S
content. But that will not be confirmed until we get a service
rig on the hole, which is imminent, to cover the remaining drill string,
complete the well and put it on a production test.

knowledge of the hazards of the well required that the hazards be contained and controlled before they could be accurately measured. Thus plausible measures of the true nature of the hazard were elusive. Even after the blow-out, the potential flow rate and H_2S content had not been determined.

H_2S content estimates

The analysis has demonstrated the technical difficulties of precisely measuring or quantifying the features of the incident. The lack of precision meant that the quantifiers which were produced were not highly plausible. Nonetheless, actions were taken by Amoco based on the assumption that the incident was relatively accurately measured and assessed, even when this was not the case. Exhibit 4 displays key testimony concerning the processes by which estimates of the H_2S content of the flow were obtained. It also contrasts the state of knowledge about the flow at the time it occurred with knowledge available later in the inquiry.

Knowledge of H_2S content is presented here as an 'estimate' and not as a precise measure. Mr Neidermayer indicates the limited plausibility of his claims by stating 'this is purely speculative' (line 10). An estimated flow of 20 million cubic feet per day is a subjectively based claim which 'appears in our mind' (lines 12–13). This uncertain figure is treated as more plausible than the on-site estimates made at the time of the flow, and the on-site estimates are now treated as highly inaccurate (lines 15–16). The basis for quantification is again subjective experiences using natural senses: one's sensing of 'the amount of fumigation that occurred' (lines 18–19). Mr Neidermayer claims it is difficult to 'come up with a specific number' but he nonetheless provides a rather specific number: between 10 and 20 per cent H_2S content in the flow (lines 21–23). Thus an ironic contrast is created between the measures which are uncertain subjective estimates and the precise numerals which are attached to these subjective estimates, which further reduces the plausibility of the quantitative descriptors of the flow.

The plausibility of 'ball park estimates' is based in subjective perceptions of technically credible personnel: 'the consensus of a number of people that had seen flows from wells' (lines 31–32). Visual evidence of the direction and location of the flow (lines 32–33) and of its velocity (line 34) are the basis of precisely stated measures of the flow, and these are based in subjectivity: 'the velocity of the flow suggested it was pretty substantial ... 20 million a day looked pretty good' (lines 34–36). The transition from subjectively experienced cues to objective if uncertain measurements is explained by an appeal to mathematical reasoning and practices—back calculating from conveniently available data sources. This transformation of the bases of knowledge enhances the credibility of the revised claim that the concentrations were 'very low concentrations' (line 38) but 'possibly higher than 20 million a day' (line 41). The context of the blow-out is used to establish a reasonable basis for imprecision in the quantitative descriptions of the flows.

The measures produced through calculations also make previous estimates of the seriousness of the blow-out appear problematic (lines 43–47). Yet at the time of the actual blow-out, these calculations were not available, hence perception (line 49) and feel (line 49) produced the sense that the hazards were lower than they were later determined to be. The logic underlying the initial estimates is noteworthy for the implausible premises which produced a precise yet uncertain measure: 'we kind of came to the 20 million a day conclusion' (line 26–27). The problem for personnel and investigators was thus converting a common sense object available to perceptual cues into a measurable object with precise technical features. Given that accurate measures were not available nor possible to produce, members sought and used plausible bases for making interpretations.

EXHIBIT FOUR
H_2S Content Estimates

Mr McLarty, ERCB examines Mr Neidermayer, Amoco, pp. 155–157

Q Just in connection with your last response, sir, what are your estimates now, ball park estimates, as to what the well was in fact flowing at and the H_2S content of the gas?

A Again this is purely speculative, but the rates that we have stated initially—when I say initially, kind of after this thing carried on for a day or two of 20 million appears in our mind to have been exceeded based on the numbers that we see in the dispersion of H_2S. I just can't give you a figure, but I am saying it is probably greater than the 20 million that we kind of acknowledged during the period of the blow.

The H_2S content has got to be substantial as a result of the amount of fumigation that occurred.

Again, to come up with a specific number would be most difficult, but it is certainly greater than 10 per cent and could be in the order of 20 per cent.

Q Can you tell us, Mr Neidermayer, when Amoco changed its thinking to appreciate perhaps the flow rate and the H_2S content was perhaps greater than it was initially believed, when did your thinking start to change?

A I think very early in the game we latched on to the 20 million a day, and that was the consensus of a number of people that had seen flows from wells and the acknowledgement that it was blowing up through the crown, you know, we had something in excess of 100 feet, and the velocity of the flow suggested it was pretty substantial and the consensus said that 20 million a day looked pretty good. It wasn't until we were able to back calculate based on the H_2S being monitored throughout the Province, and by the way these are very low concentrations, but because of the knowledge of wind direction and dispersions and diffusion we were able to suggest numbers that now have to be possibly higher than the 20 million a day.

Mr Neidermayer: And again, it was hard for us to believe that there was a very high H_2S concentration associated with this flow almost entirely during the blow-out period because the highest measurement we ever had was right at the well site under the substructure, and it was 500 p.p.m. Now we did see numbers that approached the 100 p.p.m. or in the immediate vicinity. And I guess just by perception we felt if that is all we are getting that close to the well site, this can't be more than 5 or 10 per cent. So it is not until we have taken the data that was placed out in the Province and kind of worked it back to the source that we have now, very recently, come to the conclusion that the flow rate and the concentrations may have been somewhat higher.

Q Sir, you indicated this took place, as you put it, very
early in the game. Would that be on December 7th, 8th, 9th?

A The 20 million?

Q Whenever your thinking started to change that you were
dealing with perhaps a larger problem than you had originally
anticipated.

A As far as the flow is concerned, I guess the 20 million
was established within a day or two. Our perception on the
H_2S concentration remained throughout, the blow in this less
than 10 per cent arena. Like I say, it isn't until now,
based on some of this other work, we feel it possibly is
higher.

Mr McLarty, I might add on that question, you will recall the diagram that we
displayed yesterday that showed how the kelly was
originally vertical in the tool joint and then a day later had
tipped.

This caused a spewing of the gas that, you know, maybe made it a little
difficult. But it was when it was spewing
and observations were made that we kind of came to the 20 million a day
conclusion.

The size of the condensate spill

Theoretically, the leak and the associated spill of condensates can be precisely and accurately measured. In practice, the assessments were imprecise and were based in subjective interpretations of cues and contextual features. Exhibit 5 reports discourse concerning estimates of the size of the condensate spill. This exhibit reveals the ambiguity and uncertain nature of precise measures and the difficulty in establishing credible, objective measures of the flow's size. Here, the adjectives large and small are linked to quantities in a manner which makes the size of the spill highly ambiguous. For example, Mr Kupchanko inquires whether 6000–10,000 barrels is a large or small spill relative to other spills. Mr Findlay from Amoco uses his subjective experiences ('I feel', lines 12–13) to claim it is a small spill. While it might be helpful to Amoco if the spill is seen as 'small', it does seem that 6000 barrels is a substantial and meaningful amount of spillage. Thus the adjective 'small' is given plausibility through reasoned speculation which relies on contextual features. The spill is interpreted as small, not large because it is smaller than other spills (line 14). It occurred on the frozen surface (snow) and not on the actual humus layer of the forest. It might evaporate and hence diminish in size (line 19) and indeed the spill has already diminished due to run-off into the river. Finally, by the time that final estimates are done ('I think it is *going to*', line 21, emphasis added) it will be quantifiable as a 'pretty small spill'. These contextual features provide the bases for the meaning of the size of the spill and for the interpretations given to the numerals used to represent size. The adjectives and numerals themselves are not meaningful. Further, many of the contextual features which are used to interpret the size of the spill are prospective features which emerged or are expected to emerge between the time the

EXHIBIT FIVE

The Size of the Condensate Spill

Mr Kupchanko, ERCB Board examines the Amoco panel, p. 199.

Q **Mr Kupchanko:** Mr Findlay, you mentioned that between six
to ten thousand barrels of condensate were spilled on the
lease on the site. In your experience, is this a large spill or a
small spill compared to other spills?

A **Mr Findlay:** For the area that it covered, I
feel it is a relatively small spill. And the reason I say it is
a small spill is in relationship to other spills, we have
the surface layer, the humus layer, usually in the forest
situation saturated. In this case we don't have a
saturation of that forest level. It is still in the snow, tied
up in the snow that is evident there. And as a result I think it
is going to be relatively small because we have evaporation
going on, we have a certain amount of movement already that
has gone into the Pembina River and I think it is going to
amount to a pretty small spill.

spill originated and some future time when it can be more precisely assessed. Thus the spill is a small spill because subjectively that is how it is viewed. Plausible contextual reasons can be given for interpreting it as small. And it is reasonable to assume that factors will diminish its size such that one can interpret the spill in terms of what it will become, not in terms of what it is now or was at an earlier time.

Analysis of Textual Tables

The analysis below addresses the meanings of each of the two sets of key words—hazards and measures. I first address the general meanings of the terms as evidenced by an index of all occurrences of the words. Then I present and discuss the specific meanings of the key words held by each of the two theoretically relevant groups, as evidenced by key word in context displays for each group. This analysis reveals the general meanings of the terms and also the different meanings held by each of the two theoretically meaningful groups, the ERCB as a regulator and Amoco Canada as the operating company.

Hazards

Hazards were extensively thematized during inquiry discourse. This is revealed by Table 2 which provides an index or listing of all uses of hazard-related key words (hazard, $n = 48$; hazardous,

Table 2. Hazard key words index

hazard (48)

(82) of a similar occurrence; | (d)the >hazard to people which may
(372) that an immediate | public >hazard was unlikely. The
(386) of the blowout and the | potential >hazard from the well.
(473) of the blowout and the potential >hazard and was given | a
(581) created a potential sulphur dioxide >hazard. | Subsequently the
(589) bothersome, was not a serious >hazard to | the public. In
(667) impact, particularly in terms of >hazard to human health, of |
(702) | rate, no imminent environmental >hazard to area residents was |
(814) public fears about the | toxic >hazard of this obnoxious air
(889) were not aware of the extent of the >hazard | involved. In all
(902) preparations began to assess the >hazard potential of the |
(989) municipal | authorities as to the >hazard and potential
(1244) the report, that is, the sour gas >hazard to people. | |
(1964) Board's notice, and that is, 'The >hazard | | < p. 69 > | | to
(4004) flow from the well to be a serious >hazard to | people in the
(4007) We did not consider it a | serious >hazard. We recognized the
(4052) does constitute some degree of | >hazard to those people. Would
(4055) at times on | site represented a >hazard, one that we felt we
(4058) | that there was an additional >hazard beyond that of the H2S,
(4309) as a result of a | potential >hazard that might or could
(4341) such time as there is a definite >hazard to the | residents in
(4361) | protection from a sour gas >hazard, when Amoco moved |
(4481) activity. So there was not a >hazard created as a | result
(4681) well could have | presented a >hazard to the public? | |
(4685) demonstrate that there was no real >hazard to the public. We did
(4704) Amoco did perceive | a potential >hazard from the well, although
(4707) we | perceived a potential >hazard near Lodgepole. |
(4726) or perceived a potential >hazard for an area that could
(4728) also have recognized a | potential >hazard that could have
(4740) did not perceive that there was a >hazard that | wasn't going to
(4756) really not necessary because | a >hazard did not exist? | |
(4758) want to try | to define what a >hazard is. We felt that there
(4758) is. We felt that there was a true >hazard | on the drill site and
(4770) | is a matter of risk rather than >hazard and we feel that the
(4788) | were made aware of the potential >hazard, and we felt we had |
(4812) that | | < p. 166 > | | the biggest >hazard laid right on the well
(4847) done is because we didn't think a >hazard existed | outside the
(4894) the early stage, which was not a >hazard | situation, and
(4896) | that there could or might be a >hazard situation and I wonder
(4928) | that there was a potential for a >hazard out there. | We never
(5073) were living in, there was no great >hazard, and | they would be
(5074) | they would be monitored if the >hazard increased in content. |
(5264) of the H2S and the potential | >hazard that that had in the
(5268) that | there was a danger or a >hazard identified with the
(5293) with respect to protection of the >hazard or | damage that could
(6056) well clearly would have been, if a >hazard existed | in our minds,
(6059) | Board, that there wasn't real >hazard but the suggestion
(6066) that there would have been a real >hazard to the | surrounding

hazardous (18)

(428) are not generally considered to be >hazardous. | Board staff in
(536) at the well site were | extremely >hazardous because of the
(604) burning would have been extremely >hazardous and | was probably
(676) | residents were not subjected to >hazardous air contaminant |
(714) in | complaint or potentially >hazardous areas. | | /To

Table 2. Continued

<table>
<tr><td>(2031)</td><td>| area was indeed extremely >hazardous, and it is a trubute</td></tr>
<tr><td>(3983)</td><td>igniting it and, particularly the >hazardous effects that | could</td></tr>
<tr><td>(3985)</td><td>and | take the potentially >hazardous conditions that</td></tr>
<tr><td>(3989)</td><td>that there was no | severe >hazardous situation to the</td></tr>
<tr><td>(3993)</td><td>beyond that were not considered | >hazardous in the early going.</td></tr>
<tr><td>(4023)</td><td>to expose people to | potentially >hazardous had been high, then</td></tr>
<tr><td>(4687)</td><td>of continued surveillance, the >hazardous | situation was</td></tr>
<tr><td>(4710)</td><td>would suggest that you have got a >hazardous | area. | | /We</td></tr>
<tr><td>(4718)</td><td>period of time | are potentially >hazardous, as you heard</td></tr>
<tr><td>(4762)</td><td>clearly | have got a potentially >hazardous situation. We did</td></tr>
<tr><td>(4834)</td><td>that the public | was in a >hazardous condition. | |</td></tr>
<tr><td>(4929)</td><td>out there. | We never did have a >hazardous situation in the |</td></tr>
<tr><td>(5070)</td><td>| we hear hydrogen sulphide gas is >hazardous, is my family | in</td></tr>
<tr><td colspan="2">hazards (5)</td></tr>
<tr><td>(103)</td><td>such an event, and to minimize the >hazards | and effects of such</td></tr>
<tr><td>(891)</td><td>the people were briefed | on the >hazards of hydrogen sulphide</td></tr>
<tr><td>(908)</td><td>was not creating localized area >hazards. AMOCO was asked | to</td></tr>
<tr><td>(4297)</td><td>and discuss with you the potential >hazards | that you may have |</td></tr>
<tr><td>(4699)</td><td>| lot of people, but as far as the >hazards concerned, there</td></tr>
</table>

n = 18; and hazards, n = 5) which occurred at the inquiry, with the line number of the occurrence noted. The discussion refers to specific statements in the table. To enhance the clarity of the discussion, I refer to line numbers only with reference to quotations and other important specific claims.

Hazards in general

The concept of hazards acquires meaning as a noun and as an adjective. As a noun (hazard, hazards), hazards are the object of the inquiry itself and refer to potential dangers of the flowing well. Concerns arising from the presence of hazards include impacts on people and their health, and the emergence of a hazardous environment. The sources and nature of the hazard are addressed and include hazards from the well and from the gas itself, which is referred to as both sour gas and hydrogen sulphide. There is also concern for public fears about the toxic hazards of the obnoxious air. The quantifiable potential for hazards which is addressed includes the degree of hazard (4052) which takes three forms: a limited amount of hazards (e.g. 'no great hazard', 5073); potential yet unrealized hazards; and definite hazards. Hazards also appear as adjectives, which link hazards (nouns, objects) to other objects and processes. Hazardous conditions are a general concern. The hazards indicated in this manner include a concern for the well site and other areas made hazardous because of hydrogen sulphide gas. Burning or flaring the well (604) is a potentially hazardous action which merits particular concern.

Government conceptions of hazard

Table 3 provides a key word in context display for hazard key words used by the ERCB, followed by presentation of Amoco uses of the term. For purposes of brevity, the table reports only selected occurrences including the occurrences explicitly referenced in the discussion below.

Table 3 shows that hazards were basic to the general mandate of the ERCB. The hazards formed the rationale for holding an inquiry and were the primary concern of the ERCB at the

Table 3. Key word in context display for hazard key word uses by Alberta ERCB and Amoco

Alberta Energy Resources Conservation Board
(103) set out in the notice of inquiry such that it may better determine what, if any, measures may be necessary to avoid a similar occurrence of such an event, and to minimize the hazards and effects of such an occurrence if one should take place./Mr E. Kupchanko, Assistant Deputy Minister of Alberta
(372) and for the hydrogen sulphide content of the gas which was believed to be less than 5 per cent, it was concluded that an immediate public hazard was unlikely. The immediate concern was for those members of the drilling crews and camp in the vicinity of the well.
(428) H_2S concentrations (less than 2 parts per million). While such levels may cause nausea and minor irritations to certain individuals they are not generally considered to be hazardous. Board staff in Calgary and Drayton Valley decided that hydrogen sulphide concentrations in excess of 10 parts per million would
(536) Board staff was aware that conditions at the well site were extremely hazardous because of the hydrogen sulphide gas and liquid hydrocarbon on the lease area. To my knowledge at least four persons were treated at the Drayton Valley Hospital for
(604) prevented by using dikes or trenches around the lease, the construction of such facilities during the time the well was blowing but not burning would have been extremely hazardous and was probably best not attempted. To prevent the migration of more liquid hydrocarbon on to the river, AMOCO constructed a
(3983) merit of whether to ignite the well or not and how it weighed the effects of letting the well flow uncontrolled without igniting it and, particularly the hazardous effects that could potentially be caused to people in the vicinity and take the potentially hazardous conditions that would exist to
(4004) us, Mr Neidermayer, is that weighing the situation you did not consider the H_2S flow from the well to be a serious hazard to people in the vicinity that would justify igniting the well?
(4052) other people on site while this well was blowing. I am suggesting to you, sir, that that does constitute some degree of hazard to those people. Would you agree with that? /((A)) < < AMOCO > > {MR. NEIDERMAYER}: Yes, I think the fact that
(4297) Gentlemen, if I may, I would like to take a few moments and discuss with you the potential hazards that you may have perceived or may have existed as a result of this well
(4704) /((Q)) < < ERCB > > {MR. McLARTY}: If I understand you correctly, Mr Neidermayer, you are indicating to us in fact Amoco did perceive a potential hazard from the well, although not one that would cover a great distance. Is that the case?
(4756) protected, steps and measures were taken out of an abundance of caution and in your opinion were really not necessary because a hazard did not exist? /((A)) < < AMOCO > > {MR. NEIDERMAYER}: I guess might want a try
(4894): I apologise for persisting on this point, Mr Neidermayer, but I am having a problem with the perception by Amoco at the early stage, which was not a hazard situation, and apparently that it did recognize at a later stage that there could or might be a hazard situation and I wonder if
Amoco Canada
(1244) including eight years of work in Drayton Valley in engineering and operating. Mr Burns will present part (d) of the report, that is, the sour gas hazard to people. /Seated at the back table is Mr Ron

(*Table continues on next page*)

Table 3. Continued

(1964) /I intend to discuss matters pertinent to section (d) of the Board's notice, and that is, 'The hazard < p. 69 >

(2031) presence of inflammable gas, inflammable condensate, and extremely poisonous H_2S, that the work in the immediate wellsite area was indeed extremely hazardous, and it is a tribute to the staff of the various companies involved in capping the well that no serious injuries occurred. We should mention,

(3989) {MR. NEIDERMAYER}: Well, to start with, the premise that we proceeded on acknowledged that there was no severe hazardous situation to the personnel involved on site because we could protect that, and we demonstrated we were able to do that. The hydrogen sulphide

(3993) we demonstrated we were able to do that. The hydrogen sulphide concentrations that extended beyond that were not considered hazardous in the early going. Now we did see some concentrations that precipitated the implementation of evacuation procedure for the Lodgepole and surrounding community and, as you are aware, we

(4007) {MR. NEIDERMAYER}: We did not consider it a serious hazard. We recognized the possibility of some problems and we commissioned a procedure to take care of the event that high concentrations could have been

(4023) the evacuation was rather low, we felt that that was a risk worth taking. If the suggestion that we were going to expose people to potentially hazardous had been high, then I guess we would have had a more difficult decision to make.

(4055) {MR. NEIDERMAYER}: Yes, I think the fact that the H_2S was present in relatively high concentrations at times on site represented a hazard, one that we felt we could deal with. /Q MR. McLARTY: Do you agree with me, Mr

(4341) pretty firm plan of what to do. But we don't have all this equipment of all these plans that are detailed in isolated areas until such time as there is a definite hazard to the residents in the vicinity.

(4481) southeast wind that moved this material to the northwest to an area that was really truly remote, short of a rig or two and some seismic activity. So there was not a hazard created as a result of the fortuitous situation of the wind.

(4685) occurred for a long enough period and there was sufficient monitoring undertaken during the period of the flow to demonstrate that there was no real hazard to the public. We did have the one rather delicate situation in the vicinity of Lodgepole and because of continued surveillance, the hazardous

(4699) Certainly there was a noxious odour that emanated long distances and created discomfort for a lot of people, but as far as the hazards concerned, there really wasn't one short of the vicinity I have just described, and we feel like we had a program to control that if the need arose.

(4718) significant distance from the well site itself. But the 10 parts per million arena for extended period of time are potentially hazardous, as you heard yesterday, to the invalid, the young and so on. And it was that that we were concerned about and that that we were attempting to protect by

(4740) workers outside of our drill site. They in turn were monitoring themselves to insure the protection of their people. So we again did not perceive that there was a hazard that wasn't going to be observed and which in turn would have permitted evacuation should it have gotten high.

(4758) {MR. NEIDERMAYER}: I guess might want to try to define what a hazard is. We felt that there was a true hazard on the drill site and I am going to refer to the 100 parts per million H_2S number that is generally accepted, certainly within

(4758) /((A)) < < AMOCO > >{MR. NEIDERMAYER}: I guess might want to try to define what a hazard is. We felt that there was a true hazard on the drill site and I am going to refer to the 100 parts per million H_2S number that is generally accepted, certainly within

(4770) had numbers 5 to 6 parts per million, in one instance approaching 12 parts per million for a short period of time. So it is a matter of risk rather than hazard and we feel that the risk was acknowledged and measures were taken to secure the situation.

(4788) are I believe, three farms or ranches and these sites were known, these sites were visited, people were talked to, they were made aware of the potential hazard, and we felt we had them in mind and they were secure as well. Additionally, these people were outfitted with these break ampules that, you know,

(4812) the biggest hazard laid right on the well site. As Mr Neidermayer pointed out earlier, we thought the content was relatively low, the H_2S content was relatively

(4847) {MR. BURNS}: No, that is not right. The reason it was not done is because we didn't think a hazard existed outside the immediate vicinity of the well site.

(4928) that there was a potential for a hazard out there. We never did have a hazardous situation in the community out there, short of some people that were young or

(4929) that there was a potential for a hazard out there. We never did have a hazardous situation in the community out there, short of some people that were young or infirmed in Lodgepole. And, of course, they were removed to

(5070) /As I pointed out earlier, the complaint was invariably the smell, and what is going on; we hear hydrogen sulphide gas is hazardous, is my family in jeopardy. We would take readings at the site and try to assure them and comfort them that while this was a noxious

(5073) in jeopardy. We would take readings at the site and try to assure them and comfort them that while this was a noxious condition they were living in, there was no great hazard, and they would be monitored if the hazard increased in content.

(5264) hydrocarbons. Other than this we did no physical disturbance in the area, because of the nature of the H_2S and the potential hazard that that had in the immediate vicinity within the isopleth, in the 100 parts per million isopleth that we identified.

inquiry. Thus the ERCB sought to determine the extent of the hazards, and the measures or actions which could minimize these hazards (e.g. 103). The extensiveness of hazards was addressed by seeking precise quantitative measures of the technical features of the flow and by attempting to relate these features to quantifiable standards for determining the existence of a hazard. Concentrations of less than 2 p.p.m. were determined not to be hazardous even though they can cause health effects such as nausea. The concentration of hydrogen sulphide in the flow was actually 'believed' to be less than 5 per cent, allowing the ERCB to conclude that the quantitative evidence revealed 'no immediate public health hazard' (372). However, the well site was extremely hazardous and remedial measures to control the well were regarded as 'extremely hazardous' (604) in the presence of H_2S. Also, burning the H_2S transformed it into SO_2 and this created a different hazard (536). Contextual factors and considerations limited concerns for the hazardous nature of the H_2S. For example, the feeling that 'control of the well was imminent' (589) impacted ERCB actions. Therefore, from the point of view of the ERCB, the blow-out created a potential hazard for the public and for workers. The issue was thus establishing the actuality of the hazards which arose. The government agency developed tacit rules of thumb regarding acceptable levels of H_2S. They used these rules of thumb to interpret the hazards and to question Amoco about the potential for hazards from H_2S and from ignition of the well. The questioning implied that Amoco saw the hazard (4704) and yet denied there was a hazard (4756, especially 4894), a matter of some concern to the ERCB.

Amoco conceptions of hazards

Amoco (see Table 3 above) constructed 'sour gas' as a hazard to people and addressed the Board mandate related to hazards. For Amoco, determination of hazards required monitoring which included efforts to quantify properties of the leak. Indeed quantification was basic to detecting properties of the leak which could motivate action. A definite hazard could be established quantitatively using two informal criteria: the '100 parts per million H_2S number that is generally accepted' (4758) or as 'something in excess of 10 parts per million for an extended period of time' (4718). Equipment would be arranged and definite plans would be developed only once a definite hazard was established (4341). Evacuation is one procedure to reduce hazards to local populations. Evacuation could be included in plans and procedures to be enacted if 'high concentrations' were found to reveal true hazards (4007).

Amoco's consideration of hazards was directed at local conditions faced by company personnel. Working in the areas of the well site was 'the biggest hazard' (4812). This work was regarded as 'extremely hazardous' due to the presence of inflammable gas condensate and 'extremely poisonous H_2S' (2031). Amoco thus acknowledged the existence of hazards. But Amoco also considered the hazards to company personnel to be less significant than they might otherwise be due to locally available safety strategies that could presumably 'protect' personnel (3989) on site. In addition, on-site hazards were mitigated by local conditions such as winds (4481). Amoco also initially denied that off-site hazards existed and they claimed this actual quantitative monitoring revealed 'no real hazard to the public' (4685). When quantifiable 'concentrations' of these (3993) off-site hazards were apparently observed the concentrations 'precipitated' implementation of an evacuation plan and other 'procedures' which were thought to pre-empt hazards (3993). But in general, although the actual hazards were regarded as somewhat vague and uncertain, they were viewed as hazards 'we could deal with' (4055). That is, the hazards were acceptable since they were controllable through local practices that could be enacted at or near the site of the leak.

The nature of hazards was an important theme addressed in the Amoco discussion, and this further indicates the uncertainty concerning hazards. Many statements seek to distinguish seemingly true hazards from a variety of other types of hazards. Thus there are true hazards which arise on the drill site and which are operationally defined as 100 p.p.m. concentrations of H_2S (4758), a generally accepted criterion (4762). This reflects concern with discrete measures of hazards, e.g. the 100 p.p.m. isopleth, or contour line drawn on a map to indicate where the 100 p.p.m. concentrations are located (5264). A real hazard would have been cause for flaring (5056). Hazards are also distinct from risks, and again this distinction is based on quantification: from 5–12 p.p.m. is considered 'risk rather than hazard' (4770) and the measures needed are those to secure the situation, as opposed perhaps to evacuation. Realized hazard is also distinguished from potential hazards and from hazards that impact a limited class of social actors. For example, special hazards which are discounted include hazards which impact only invalids and young (4718). Hazards which cannot be observed are distinguished from those which can be observed (4740). Yet it is only where the observable hazards are 'high' that they impact actions. Thus Amoco claims there were no real hazards off site (4847, 4928, 4929)—there were simply noxious conditions (5070) and discomfort (4699) which were 'no great hazard' (5073) although different circumstances could have created a hazard which required flaring.

Measures

Measures in general

Measurement related terms were also extensively addressed in discourse. The key words addressed here include: measure, measured, measurement, measurements, measures and measuring. Table 4 provides an index of all uses of measurement terms indicating the organization and line number for every use of the term. Table 5 provides a key word in context display for ERCB and Amoco Canada uses of measurement terms. Two basic meanings are clearly evident: measure and measures are nouns which refer to work practices and standard procedures, for example, a measure to control the blow-out (5663). Measure and measures are used also as verbs meaning to assess or quantify, e.g. 'measure the concentration' (1089). More specifically, the two meanings are measure as procedure and measure as quantification.

ERCB conceptions of measures

For the ERCB (Table 5) the procedural meaning of measures was used to refer to measures to avoid a similar occurrence. Measures or procedures were considered to be a means to pre-empt hazards and dangers. These measures were needed to protect the public against risk and to protect the environment of the leak area including river and water quality. In general, there was concern to establish measures to minimize the effects of this and other blow-outs. And there was consideration of measures or actions other than monitoring which could be taken. Measurement as a process of quantification was addressed through very extensive discussion of the issue of the accuracy of measures including consideration of conditions which effect accuracy. There was also considerable discussion of the methods for actually producing measures, including extensive discussion of the manual measurement method.

Amoco Canada conceptions of measurement

Amoco (see Table 5) uses measures to refer to procedures to reduce the hazard, and it distinguishes general measures from remedial measures and from safety measures. Thus all uses of measures as procedures address issues related to safety logics which might control the risks. The

Table 4. Index for all occurrences of measurement key words

<table>
<tr><td colspan="2">measure (11)</td></tr>
<tr><td>(Alberta Environment, 1089)</td><td>tried to >measure the | concentration,</td></tr>
<tr><td>(AMOCO, 1366)</td><td>to later, is designed to | >measure the amount of gas</td></tr>
<tr><td>(AMOCO, 2329)</td><td>really indicative of any | >measure of the change in the</td></tr>
<tr><td>(AMOCO, 2445)</td><td>to collect a sample and | >measure it. It does, however,</td></tr>
<tr><td>(AMOCO, 2875)</td><td>I would think we could >measure to | the | accuracy</td></tr>
<tr><td>(AMOCO, 4613)</td><td>They were there as a safety >measure. So as | those people</td></tr>
<tr><td>(AMOCO, 4822)</td><td>our own apparatus, would >measure | the atmosphere, find</td></tr>
<tr><td>(AMOCO, 5176)</td><td>we see there we | did not >measure any concentration</td></tr>
<tr><td>(AMOCO, 5423)</td><td>pointed out we | can't >measure the concentration of</td></tr>
<tr><td>(ERCB, 5611)</td><td>full implementation of that >measure? | |</td></tr>
<tr><td>(ERCB, 5663)</td><td>be implemented as a | future >measure to control such an</td></tr>
<tr><td colspan="2">measured (1)</td></tr>
<tr><td>(ERCB, 2935)</td><td>accuracy | that it could be >measured under the</td></tr>
<tr><td colspan="2">measurement (14)</td></tr>
<tr><td>(ERCB, 2867)</td><td>sir, would | this manual >measurement method have? | |</td></tr>
<tr><td>(ERCB, 2874)</td><td>tank. | Would your manual >measurement detect that? | |</td></tr>
<tr><td>(ERCB, 2880)</td><td>| accuracy | of the manual >measurement | | < p. 100 > |</td></tr>
<tr><td>(ERCB, 2886)</td><td>problem | in this manual >measurement method. | |</td></tr>
<tr><td>(ERCB, 2899)</td><td>any effect on | the manual >measurement method itself,</td></tr>
<tr><td>(ERCB, 2968)</td><td>have been used for accurate >measurement— | would you</td></tr>
<tr><td>(ERCB, 2970)</td><td>likely reveal accurate | >measurement? | |</td></tr>
<tr><td>(AMOCO, 2972)</td><td>provided | more accurate >measurement than we had. | |</td></tr>
<tr><td>(ERCB, 2974)</td><td>used | for more accurate >measurement of the hole fillup</td></tr>
<tr><td>(ERCB, 3035)</td><td>calculated risk and using a >measurement | method that was</td></tr>
<tr><td>(AMOCO, 4545)</td><td>period because the highest >measurement we ever had was</td></tr>
<tr><td>(AMOCO, 5178)</td><td>in the 18 days we had | a >measurement of 1 part per</td></tr>
<tr><td>(AMOCO, 5182)</td><td>point in time | it had a >measurement greater than 1</td></tr>
<tr><td>(ERCB, 6216)</td><td>I see. Sir, with the >measurement or | gauging that</td></tr>
<tr><td colspan="2">measurements (10)</td></tr>
<tr><td>(Alberta Environment, 1093)</td><td>sulphide | >measurements in the area of</td></tr>
<tr><td>(AMOCO, 2260)</td><td>should | provide accurate >measurements of the volume</td></tr>
<tr><td>(AMOCO, 3042)</td><td>| We had accurate hole fill >measurements during those</td></tr>
<tr><td>(AMOCO, 3045)</td><td>involved here, that our | >measurements were | | < p</td></tr>
<tr><td>(AMOCO, 5193)</td><td>confirming that | we had >measurements at Sunchild at</td></tr>
<tr><td>(AMOCO, 5232)</td><td>came back with only trace | >measurements, which indicates</td></tr>
<tr><td>(ERCB, 5656)</td><td>will | provide accurate >measurements of volumes</td></tr>
<tr><td>(AMOCO, 5667)</td><td>hole fill tank and taking | >measurements rigorously. On</td></tr>
<tr><td>(AMOCO, 5997)</td><td>and I don't have the exact >measurements | or dimensions</td></tr>
<tr><td>(ERCB, 6219)</td><td>and completing those >measurements? | | /((A)) < < S</td></tr>
<tr><td colspan="2">measures (20)</td></tr>
<tr><td>(???, 80)</td><td>well under control; | | (c)the > measures necessary to reduce</td></tr>
<tr><td>(ERCB, 102)</td><td>| determine what, if any, >measures may be necessary to</td></tr>
<tr><td>(AMOCO, 1269)</td><td>report, that is, the >measures | necessary to reduce</td></tr>
<tr><td>(AMOCO, 1464)</td><td>to earlier is a unit that >measures the | amount of gas</td></tr>
<tr><td>(AMOCO, 2205)</td><td>of inquiry, namely the | >measures necessary to reduce</td></tr>
<tr><td>(AMOCO, 2207)</td><td>possible | future remedial >measures, I would like to make</td></tr>
<tr><td>(AMOCO, 2249)</td><td>possible future remedial >measures that could be |</td></tr>
<tr><td>(ERCB, 4752)</td><td>to | us that in fact the >measures and steps taken to</td></tr>
<tr><td>(ERCB, 4754)</td><td>be | protected, steps and >measures were taken out of an</td></tr>
<tr><td>(AMOCO, 4771)</td><td>risk | was acknowledged and >measures were taken to secure</td></tr>
</table>

Table continued on next page

Table 4. Continued

<table>
<tr><td>(ERCB, 4772)</td><td>And Amoco then adopted >measures and | agreed that</td></tr>
<tr><td>(ERCB, 4773)</td><td>measures and | agreed that >measures were necessary to</td></tr>
<tr><td>(ERCB, 4777)</td><td>Mr Neidermayer, what | >measures were taken beyond the</td></tr>
<tr><td>(AMOCO, 4889)</td><td>site, we then did take >measures, in | concert with</td></tr>
<tr><td>(ERCB, 5254)</td><td>is what specific steps or >measures were taken by | Amoco</td></tr>
<tr><td>(ERCB, 5274)</td><td>dealt | with | the steps and >measures that have been taken</td></tr>
<tr><td>(ERCB, 5305)</td><td>that no steps or >measures were taken to | try</td></tr>
<tr><td>(ERCB, 5375)</td><td>| or would take any steps or >measures to insure that that</td></tr>
<tr><td>(ERCB, 5593)</td><td>your report dealing with the >measures | necessary to reduce</td></tr>
<tr><td>(ERCB, 5604)</td><td>that one of the primary | >measures should be to provide</td></tr>
<tr><td>measuring (1)</td><td></td></tr>
<tr><td>(AMOCO, 2888)</td><td>| considered when you are >measuring surface volumes in a</td></tr>
</table>

process of measurement is addressed in terms of a process for generating accuracy in measures and consideration is given to rigorous measures (5667) and the exact dimensions of measures (5997). Extensive consideration is also given to the objects of measurement such as the amount of gas (1366), surface volume (2885), hole fill measurements (3042), and the atmosphere (4822). The location of measurements is also an important consideration (5193). Thus in addressing measures and measurement, Amoco focuses extensively on the process of quantifying features of the leak or gas, and on issues which impact the accuracy of measures.

The discussion above, based on the data in Table 5, indicates two rather specific meanings of measurement were employed with differential frequency by each group. Table 6 summarizes the actual frequencies of these uses for each group. Both organizations use measurement words 27 times. The ERCB uses the procedural meaning of measurement in 13/27 cases and it used the quantitative meaning in 14/27 occurrences. This contrasts with Amoco which has 6/27 procedural uses and thus 21/27 quantitative uses. The ERCB thus employs the procedural meaning more frequently than Amoco, and Amoco uses the quantification meaning more frequently than the ERCB.

Analysis of Collocations

The emergent findings suggest different concerns, logics and vocabularies were used by the ERCB as the government regulatory organization and by Amoco Canada as an operator organization. The government uses a step logic, as outlined by Baccus (1986), to emphasize generalized and sequential policies which can pre-empt hazards and provide for safety. Governmental concerns over hazards and measures emphasize meanings consistent with top-down formal safety logics. Thus the government gives particular attention to formal devices and procedures used to control hazards. It addresses steps to manage hazards and steps or procedures used in the measurement process. Particular consideration is given to steps which produce accurate measures, since these are needed to establish plausible bases for implementation of control strategies and procedures. In contrast, Amoco Canada as an operator organization emphasizes personal safeguarding logics and local features of hazards. Amoco also emphasizes local contingencies which compromise procedures and regulations and which demand *ad hoc* practices. Measures refer to local actions

Table 5. Key word in context displays for measurement key word occurrences Alberta Energy Resources Conservation Board and Amoco Canada

Alberta Energy Resources Conservation Board

(102) The board intends to inquire into the various matters that are set out in the notice of inquiry such that it may better determine what, if any, measures may be necessary to avoid a similar occurrence of such an event, and to minimize the hazards and effects of such an occurrence if one should take place.

(2867) {MR. McLARTY}: What degree of accuracy, sir, would this manual measurement method have? /((A)) < < AMOCO > > {MR. HOLAN}: I would have to think of that just

(2874) the hole with some 4.65 barrels, which would result in some 0.28 inches drop in the tank. Would your manual measurement detect that? /((A)) < < AMOCO > > {MR. HOLAN}: I would think we could measure to

(2880) {MR. McLARTY}: Sir, you indicated that the accuracy of the manual measurement < p. 100 >

(2886) to be, in the order of minus 35 degrees Celsius, which, as I understand it, would create some additional problem in this manual measurement method. /((A)) < < AMOCO > > {MR. HOLAN}: Normally, the temperature is not

(2899) {MR. McLARTY}: My question to you, sir, is really this. Would the extremely cold temperatures have any effect on the manual measurement method itself, which would tend to give an answer which was somewhat less than correct?

(2935) {MR. McLARTY}: Within the degree of accuracy that it could be measured under the conditions? /((A)) < < AMOCO > > {MR. HOLAN}: Yes, sir.

(2968) {MR. McLARTY}: Gentlemen, since it was there and probably could have been used for accurate measurement—would you agree with me it would likely reveal accurate measurement?

(2970) probably could have been used for accurate measurement—would you agree with me it would likely reveal accurate measurement? /((A)) < < AMOCO > > {MR. HOLAN}: The trip tank would have provided

(2974) {MR. McLARTY}: Q And if it could have been used for more accurate measurement of the hole fillup during trips, can you explain to us why it wasn't being used?

(3035) {MR. McLARTY}: I see. I take it then, sir, that Amoco simply took a calculated risk and using a measurement method that was less accurate than one that was available to it in the interest of saving some time?

(4752) {MR. McLARTY}: Mr Neidermayer, let me make sure I fully understand you on this point. Are you suggesting to us that in fact the measures and steps taken to insure the general public would be protected, crews in the area would be protected, steps and measures were taken out of an abundance

(4754) us that in fact the measures and steps taken to insure the general public would be protected, crews in the area would be protected, steps and measures were taken out of an abundance of caution and in your opinion were really not necessary because a hazard did not exist?

(4777) {MR. McLARTY}: And then, Mr Neidermayer, what measures were taken beyond the monitoring, the helicopter reconnaissance? For example, you

(5254) {MR. McLARTY}: What I was hoping that you would tell us, Mr Findlay, is what specific steps or measures were taken by Amoco during the term of the blowout to minimize the effects that could result from the hydrocarbon liquids, what concrete steps,

(5274) {MR. McLARTY}: Mr Findlay, your panel has dealt with the steps and measures that have been taken, particularly after the well was brought under control, to protect the liquid hydrocarbon from entering the Pembina River. I wonder if you can

(5305) {MR. McLARTY}: Do I take it, sir, that while the well was flowing uncontrolled that no steps or measures were taken to try and preclude the liquid hydrocarbon entering the Pembina River stream?

(5375) {MR. McLARTY}: If in fact a returning problem should occur, sir, could you tell us whether Amoco has any plans or would take any steps or measures to insure that that water supply is protected?

(5593) Neidermayer, I am coming very close to the end of the questions I have for you and your panel and I would like to discuss with you finally that aspect of your report dealing with the measures necessary to reduce the possibility of a similar occurrence, and you addressed yourself to these matters yesterday and I think on

(5604) being accomplished and, particularly perhaps we could deal with these one at a time you indicate that one of the primary measures should be to provide continued emphasis on training for drilling crews on kick control procedures, particularly on kick control procedures while tripping. If I

(5611) opposed to discussed. Do you see that, sir, as being the full implementation of that measure? /((A)) < < AMOCO > > {MR. NEIDERMAYER}: I guess I don't understand

(5656) to insure that the system being used to fill the hole on trips will provide accurate measurements of volumes required to fill the hole. Again, sir, it seems to me it is probably not only a desirable objective but a very, very necessary one. I

(6219) gauging that was utilized, and having regard for the apparently bitterly cold temperatures, did that present a problem in actually undertaking and completing those measurements? /((A)) < < S & T Drilling > > {MR. ARCHIBALD}: I really don't know. I

Amoco Canada
(1269) Mr Neidermayer will deal with part (c) of AMOCO's report, that is, the measures necessary to reduce the possibility of a similar occurrence, and he will answer all policy questions directed to the

(1366) pushers', engineers', and mud loggers' shacks. The mud logging unit, which we will refer to later, is designed to measure the amount of gas released from drilling mud. The next slide, please.

(2207) measures necessary to reduce the possibility of a similar occurrence. By way of leading up to our conclusions on possible future remedial measures, I would like to make some summary observations based on the presentations you have just heard and seen.

(2249) /Now we have in our report submitted four possible future remedial measures that could be considered, and these are as follows.

(2260) Second, we feel that we should ensure that the system being used to fill the hole on trips should provide accurate measurements of the volume required to fill the hole. In this instance good oilfield practice was being used to keep the hole filled during the trip, but as a

(2329) weight was the situation prior to penetrating the productive horizons so the comparison is not really indicative of any measure of the change in the gas capacity of the mud. /((Q)) < < Gulf Oil > > {MR. HUTZAL}: All right. Okay. I think

Table 5. Continued

(2445) don't at this point know what the H_2S content of this well is because we have not had an opportunity to collect a sample and measure it. It does, however, to be somewhat higher than had been expected when we entered this exploratory effort.

(2875) Would your manual measurement detect that? /((A)) < < AMOCO > > {MR. HOLAN}: I would think we could measure to the accuracy of a quarter of an inch.

(2972) {MR. HOLAN}: The trip tank would have provided more accurate measurement than we had. /((Q)) < < ERCB > > {MR. McLARTY}: Q And if it could have been used

(3042) risk. We had a PVT system on the main (land) system. We had made 5 previous trips with this identical system. We had accurate hole fill measurements during those previous five trips with this fill circulating system as hole fill. And there apparently was no particular risk involved here, that our

(4613) rig, were wearing breathing air apparatus but the safety line had people with airpacks on their backs but they weren't using them. They were there as a safety measure. So as those people now were starting to be exposed to these higher concentrations, we assumed a fallback until the air

(4822) from people we know in the area, then we became more aware, you know that this H_2S at low levels was getting out. We answered the complaints. We went down with our own apparatus, would measure the atmosphere, find relatively low H_2S levels but enough they would have concern, mainly based on the odour.

(4889) because we didn't perceive that there was a public problem. As time evolved and the odour complaints emanated quite long distances from the drill site, we then did take measures, in concern with Alberta Environment and others, to communicate the problems with regard to H_2S to the public.

(5176) well, that we did read something in excess of 1 part per million. Outside of that balloon that we see there we did not measure any concentration greater than 1 part per million. Inside that on a spot in the 18 days we had a measurement of 1 part per million or greater. Okay?

(5178) did not measure any concentration greater than 1 part per million. Inside that on a spot in the 18 days we had a measurement of 1 part per million or greater. Okay? /((Q)) < < ERCB > > {MR. McLARTY}: Yes, sir.

(5182) {MR. NEIDERMAYER}: So it looks to me like Sunchild is inside that and suggests that at some point in time it had a measurement greater than 1 part per million, okay? /((Q)) < < ERCB > > {MR. McLARTY}: Thank you very much, sir.

(5193) {MR. NEIDERMAYER}: We are now confirming that we had measurements at Sunchild at greater than 1 part per million, and that the contouring is correct, and I guess our text may warrant further correction.

(5232) detect it through smelling. We took samples of it, and we had them analyzed, and they came back with only trace measurements, which indicates that our evolutionary process in the human physiology exceeds the technology currently available.

(5423) hydrocarbon chain and we just don't seem to be collecting an awful lot of material. Ron has already pointed out we can't measure the concentration of it but by odour and taste, perceptively it's there.

(5667) instance, we had a preferred procedure stipulated by our own practice, which is using the hole fill tank and taking measurements rigorously. On the change out of

(5997) {MR. HOLAN}: A very rough calculation in that there are some unknowns, and I don't have the exact measurements or dimensions of the tanks and the dead wood in the tanks handy.

Table 6. Measurement terms: quantitative and procedural uses

Measurement term	Quantitative uses	Procedural uses	Total occurrences
Measure	8	3	11
Measured	1	0	1
Measurement	14	0	14
Measurements	10	0	10
Measures	1	19	20
Measuring	1	0	1

Table 7. Collocates for hazards key words

Collocates	Collocate freq.	Type freq.	*Z*-score
All occurrences			
Potential	14	26	22.674
Potentially	6	9	16.598
Real	3	4	12.477
Recognized	3	5	11.107
Serious	3	7	9.298
Perceived	3	8	8.656
Public	6	30	8.640
Situation	6	34	8.036
Extremely	3	11	7.275
Hazard collocates: ERCB			
Potential	8	26	21.488
Public	3	30	7.236
Hazard collocates: Amoco Canada			
Real	3	4	18.324
Potentially	3	9	12.081
Potential	4	26	9.256
Situation	4	34	7.984

required by the object itself and to quantitative representations relevant to assessing local safety. Accuracy of measurement is an important concern, but it appears secondary to concern for local actions that prevent or mitigate hazards and reduce risks.

Table 7 presents the collocates for hazard-related key words and Table 8 presents the collocates for measurement-related key words. For each word the overall collocation list is presented first, followed by collocates for ERCB uses and then by collocates for Amoco uses. In this section, I interpret the collocations by discussing how they reflect similarities and differences in the vocabularies and issues addressed by each group, and how the collocates relate to the emergent theoretical insights.

The general collocations reveal that the highest overall *Z*-scores are obtained for key words relating to the uncertain nature, existence and extensiveness of the leak and its hazard to publics. In particular, the collocates 'potential', 'potentially', 'real' and 'exist' indicate a concern for generalized hazards which could emerge, not merely with those actually observed. The problematic nature of sensing and interpreting hazards is also indicated by the collocates 'recognized' and 'perceived'. The collocates reflect concern with the certainty of hazards and with the extent to which they are recognized, considered serious, and impact the public.

Table 8. Collocates for measurement key words

Collocates	Sel. node	Collocate freq.	Type freq.	*Z*-score
All occurrences				
Accurate		9	12	24.291
Accuracy		4	5	16.740
Steps		6	14	14.824
Manual		5	11	13.957
Reduce		4	9	12.337
Taken		7	28	11.998
Method		4	10	11.671
Necessary		6	34	9.153
Future		3	12	7.854
Greater		3	13	7.516
Possibility		4	23	7.411
Measurement collocates: ERCB				
Steps		6	14	21.851
Manual		5	11	20.557
Accurate		5	12	19.661
Accuracy		3	5	18.345
Method		4	10	17.221
Taken		6	28	15.262
Measurement collocate: Amoco				
Accurate		4	12	15.528
Greater		3	13	11.108

Two words—potential and public—are collocates of the hazard key words which occurred in ERCB discourse and which meet the criteria for interpretation noted above. The uses of these words shows that the ERCB emphasizes the generalized nature of the hazards, since it is potential hazards not actual hazards which are addressed. Public hazards were part of the ERCB mandate and their concern for preserving public health and safety is represented by these collocations. For Amoco the reality of hazards is the foremost collocate. The potential hazards are also important, and hazardous situations are also addressed. Amoco discourse thus appears to emphasize the reality of hazards. Less consideration is given to the potential or unrealized hazards, and some consideration is given to the local context of the hazards. The failure of 'public' to collocate with 'hazard's in Amoco discourse suggests that the issue of 'public' hazard was less of a concern for Amoco than for the ERCB. That is, the ERCB addressed public hazards more explicitly and readily than Amoco.

Measures

Table 8 displays the measurement collocates. In general, the issue of accuracy or accurate measures of the well flow is the primary issue reflected by the collocates. Steps are the next strongest collocate, reflecting a concern with sequences of action. The 'manual' method for measurement also emerges as an important collocate. The collocates in general reflect concern over the certainty of measures (e.g. 'possibility'), both as quantitative representations and as methods or steps for action designed to reduce the hazards. For the ERCB, the strongest collocate is steps, reflecting very explicitly their use of step logic. The manual measurement method is also reflected in the collocations. Accurate measurement and the quantification of the well flow are also strongly thematized. For Amoco, the two collocates which meet criteria for inclusion are accurate and greater. Both of the words reflect consideration of quantitative concerns in measurement rather than procedural concerns.

Summary of results

Inspection of the textual exhibits, textual tables and collocation displays shows that the key word indicators are embedded in discourse that reflects the differential logics of the two groups. For the ERCB, the determination of hazards is oriented to (1) steps or actions and failure to take steps or actions, and (2) precise measures as rules for action and as definitions of hazards. In terms of measures, the results indicate the ERCB used a generalized logic of control that specifies steps that are logically effective in producing safety. In contrast, Amoco addresses the reality and uncertainty of hazards in relation to local conditions which impact the safety of on-site personnel. Amoco addresses safeguarding strategies which reduce local hazards and thematize natural and local conditions which mitigate hazards. And Amoco presents reasons that the available evidence did not reflect the true hazards they appeared to assess. Amoco personnel thus address measurement as a quantification process which assesses local conditions to provide a basis for rational reactions to the event. Monitoring the leak is a primary mode of safeguarding personnel.

Research Questions and Findings

The first research question addressed how quantitative practices and terms were used in sensemaking about the organizational crisis. The second question asked how these quantification practices were related to risks and hazards. The analysis above shows that quantitative terms were used extensively as descriptors of the nature, size, and seriousness of the uncontrolled flow. Detecting and affirming the 'fact' of an H_2S leak required quantitative measures of presence of particular gases, hence quantitative terms and processes—parts per million, calculations, estimation—were basic descriptors which evidenced the existence of an H_2S leak. Since the H_2S hazard was detected by measures, quantitative terms were important representations of hazards and their extensiveness. Indeed, quantitative evidence of hazards was seemingly necessary for appropriate and/or significant hazard management activities or measures such as the evacuation of personnel and residents. Thus quantitative terms and practices were central to the transformation of subjective perceptions (e.g. odours) into objective and factual hazards.

Quantitative sensemaking distinguished risks from hazards and provided bases for classifying types of hazards, e.g. potential, realized and real. Further, quantitative terms and practices—and numerals as key quantitative symbols—provided a sense of precision and certainty about the incident which reified the facts of the incident. The espoused 'fact' that many numerals were not subject to empirical validation displays the problematic validity of the numerals—their bases and meaning were unclear. Rather, quantitative practices transformed subjective experiences, feelings, common sense terms and contextual aspects into technical discourse composed of numerals. These numerals could then be logically assessed and interpreted using procedures of mathematics and engineering. These now rather more precise descriptors can then be properly generated, interpreted and critiqued by experts using technical knowledge and terms.

However, the explicit concern for accuracy in measurement of hazards arose in the context of an implicit concern for the plausibility of measurement. This was an important concern given the widespread acknowledgement that accurate measurement was difficult if not impossible at many points. Discussions of plausibility addressed the general nature of meanings and hazards, the accuracy of specific measures of hazards obtained in the incident, and the validity of the generative processes which produced and interpreted representations and measures of hazards. Plausible reasons for inaccurate measures thus emerged as an issue. The accuracy of measurements was impacted by local conditions related to the measurement process, the obstinate features of the leak, perceptual constraints and clues, and the work activities of personnel charged with managing the leak. Quantitative terms and practices were thus composed in the context of qualitative sensemaking which uses both technical and common sense to assess the accuracy of measures and to evaluate the plausibility of measurement practices and outcomes. Plausibility thus emerged as foundational to discussion of the accuracy and usefulness of measures of hazards.

The third research question addresses the variations in quantitative sensemaking which occurred among different stakeholder groups. Here, I have examined two stakeholder groups, the ERCB which was a government regulatory organization, and Amoco Canada, a private company. Both groups used quantitative sensemaking extensively to assess hazards, to undertake and assess quantitative measures, and to warrant certain actions. For the ERCB, quantified hazards were basic to the rationale for the inquiry and for subsequent ERCB actions. Their goal was to assess the hazards, separate real from other hazards, and to assess attempts by Amoco to mitigate these hazards. An emphasis was placed on assessing, preventing and mitigating hazards to the public. The ERCB focused on both procedural measures for protecting diverse groups and resources (e.g. water) and on two quantitative measurement issues: the manual measurement method, and the accuracy of measures. This reflects their orientation to regulation and control using procedural logics of bureaucracy. In contrast, Amoco Canada viewed hazards as inherently detectable via perception, and specific quantitative measures of hazards were then artifactual or supplemental to the 'raw' experiences of odours, sight, and feelings. Hazards could be quantitatively distinguished from risks but the major response to hazards was to monitor these quantitatively, after they were perceptually noticed. Public hazards were potentially a concern, but these were quantitatively determined not to have arisen. There were only risks and noxious air emerging from the blow-out. Thus monitoring to insure the risks were not hazards could substitute for more significant actions such as enacting an evacuation. In a sense, measures are measurable for Amoco in terms of quantified features of gases and the meaning of these features in terms of local contingencies. A rather strict yet flexible quantitative criterion for determination of measured hazards was established. Thus for Amoco, there was no hazard in this case since local contingencies mediated any indications of hazards which were quantitatively evident. The quantitative discourse of the company thus shows the precedence it gives to local features of hazards and measures. The company pre-empts discussions of hazards by quantitatively transforming these into the lesser category of risks.

In summary, quantitative practices and terms are essential to determination and establishment of hazards. Quantification of hazards requires creation of measures, as quantitative representations of hazards. And quantitative representations or measures are fundamental to motivated management and technical control of the incident—an uncontrolled flow of hydrogen sulphide. Where such an 'object' cannot be precisely measured, its features are obscure and remain subjectively amorphous and uninterpretable, hence implausible. Precise measurement 'fixes' the phenomenon and transforms it from subjectively experienced signs into mathematical symbols. These symbols come to represent intersubjective and objective events and phenomena and these events then become 'objects' which are incorporated into consciousness. Measurement thus normalizes a phenomenon. It allows the phenomenon to be identified, treated as concrete, and monitored. Measurement thereby establishes the grounds for subsequent actions. Measurement and quantification thus play a central role in the management of technical meanings.

Discussion and Implications

Methodologically, the paper shows how computer-supported interpretive textual analysis can be used to address quantitative terms and concepts in use in everyday scenes of organizational discourse. Theoretical sampling and computer textual analysis software were used to create textual exhibits and tables representing patterns of meaning in the textual data. These displays provided an empirical basis for expansion analyses which compare and contrast the sensemaking of the different groups. By examining sensemaking and logics in use—as surfaced from textual data—interpretive textual analysis was used to produce insights into the tacit logics of these groups. Then, the surfaced findings were reviewed and integrated with prior theory and research by determining points of convergence and correspondence between the surfaced and the *a priori* theories. The emergent, grounded insights into members' meanings of concepts were then used to establish bases for textual statistics—countable features of discourse that are sensible to members. This iterative process thus established insights into crisis sensemaking based in observable and meaningful linkages between the concepts and meanings of members and the concepts and interests of organizational behavior.

The methodology presented in the current paper also contributes to interpretive approaches to computer-supported qualitative data analysis (Kelle, 1995). The paper outlines a means to use computers to support the tasks of interpretive analysis, including theoretical sampling. The use of expansion analyses of selected textual segments in textual exhibits incorporates fine grained hermeneutic analysis in the current approach (Lonkilla, 1995). Through the use of key words, the theoretical findings from fine grained analysis of small samples are linked to more exhaustive and comprehensive textual samples representing the entirety of the textual database. The use of key words to capture intersections in the vocabularies of social actors and organizational scientists also provides a way of linking actors' concepts to social science concepts. This contributes to efforts to implement Schutz' (1973) methodological strategy for producing interpretively valid scientific constructs by creating constructs of the constructs of social actors which summarize actors' actual meanings. This also shows that the current approach has the objective of developing and elaborating a set of key word indicators which help capture the meanings of text. This iterative development of the key word set contrasts with the process of quantitative content analysis which uses relatively fixed and pre-established dictionaries for creating measures of constructs. Finally, the approach provides a relatively direct means for linking members' meanings to textual based statistics which represent emergent conceptual and theoretical insights. This key word-based linkage strategy differs from previous, more indirect qualitative/quantitative integration strategies (Fielding and Fielding, 1986; Kelle, 1995; Kuckartz, 1995; Roller *et al.*, 1995) which rely on coding or classification of texts, and counting of the occurrence of the codes or classifications.

In general, the current study shows the important role of quantitative sensemaking in crisis discourse about one incident. It suggests quantitative sensemaking is important in other crisis incidents and in sensemaking generally. And it shows how plausibility issues are relevant to quantitative aspects of sensemaking, including the mathematical and technical practices used to generate and interpret numerals. Further, different groups and stakeholders use quantitative terms and sensemaking somewhat differently, and there is some evidence that these variations reflect underlying differences in the institutional settings, frameworks and logics of these groups. Research is needed to clarify and substantiate these findings, but they do at present suggest quantitative sensemaking is an important topic for sensemaking research and organizational behavior studies of crises, discourse, and conversational practices in organizations.

To conclude, the paper offers a computer-aided approach to interpretive textual analysis which uses textual data as a foundation for scientific representation. Quantitative organizational behavior research, like other forms of scientific research (both natural and social, Gephart, 1988a, p. 66) has neglected the qualitative, textual basis of all scientific observations. Scholars commonly attempt to circumvent the basic textuality of scientific descriptions by representing observations in numerals which are assumed to reflect human events. Yet these numerals are inextricably embedded in textual displays and common language interpretive contexts. These interpretive contexts are essential to understanding the meaning of scientific observations. The present interpretive approach can thus provide insights into the quantitative and mathematical foundations of contemporary research. It also provides a means to (re)construct organizational behavior on qualitative foundations which acknowledge and explicitly address the textual and literary bases of science.

References

Alberta Energy Resources Conservation Board. (1978a). *Proceeding No. 780023*, Edmonton, Canada.

Alberta Energy Resources Conservation Board. (1978b). *Inquiry Report 78-8, Proceeding No. 7800023*, Calgary, Canada, June 9.

Alberta Energy Resources Conservation Board (1984). *Decision D: 84-5 Lodgepole Blowout Inquiry—Phase 2: Sour Gas Well Blowouts in Alberta: Their Causes and Actions Required to Minimize Their Occurrence*, Calgary Alberta, April 25.

Baccus, M. D. (1986). Multipiece truck wheel accidents and their regulation. In: Garfinkel, H. (Ed.) *Ethnomethodological Studies of Work*, Prentice-Hall, Engelwood Cliffs, NJ, pp. 20–59.

Berger, P. and Luckmann, T. J. (1966). *The Social Construction of Reality*, Anchor Books, New York.

Bittner, E. (1965). 'The concept of organization', *Social Problems*, **32**, 239–258.

Bogdan, R. and Ksander, M. (1980). 'Policy data as a social process: a qualitative approach to quantitative data', *Human Organization*, **39**, 302–309.

Bradley, J. (1988). *T.A.C.T. Version 1.0 User's Guide*, Centre for Computing in the Humanities, Toronto.

Bradley, J. (1990). *T.A.C.T. 1.2 Update*, University of Toronto, Toronto.

Brent, D. (1994). 'Comment on "who need not be heard"', *Technology Studies*, **1**, 110–113.

Carroll, J. S. (1995). 'Incident reviews in high-hazard industries: sense making and learning under ambiguity and accountability', *Industrial and Environmental Crisis Quarterly*, **9**, 175–197.

Cicourel, A. V. (1980). 'Three models of discourse analysis: the role of social structure', *Discourse Processes*, **3**, 101–132.

Colby, N. C., Kennedy, S. and Milanesi, L. (1992). 'Content analysis, cultural grammars, and computers', *Qualitative Sociology*, **14**, 373–384.

Dey, I. (1995). 'Reducing fragmentation in qualitative research'. In: Kelle, U. (Ed.) *Computer-Aided Qualitative Data Analysis*, Sage, Newbury Park, CA, pp. 69–79.

Dow, J. (1994). 'Comment on "who need not be heard"', *Technology Studies*, **1**, 97–99.

Energy Alberta (1986). Government of Alberta, Edmonton.

Engen, A. and Gephart, R. (1986). 'The Lodgepole 1977–78 gas well blowout'. Government of Alberta, Occupational Health and Safety Heritage Grant Program, Edmonton, Alberta, Canada.

Fairclough, N. (1992). *Discourse and Social Change*, Polity Press, Cambridge, U.K.

Fielding, N. and Fielding, J. L. (1986). *Linking Data*, Sage, Newbury Park, CA.

Ford, J. D. and Ford, L. (1995). 'The role of conversations in producing intentional change in organizations', *Academy of Management Review*, **20**, 541–570.

Garfinkel, H. (1967). *Studies in Ethnomethodology*, Prentice-Hall, Englewood Cliffs, New Jersey.

Gephart, R. (1978). 'Status degradation and organizational succession: an ethnomethodological approach', *Administrative Science Quarterly*, **28**, 553–581.

Gephart, R. (1988a). *Ethnostatistics: Qualitative Foundations for Quantitative Research*, Sage, Newbury Park, CA.

Gephart, R. (1988b). 'Managing the meaning of a sour gas well blowout; the public culture of organizational disasters', *Industrial Crisis Quarterly*, **2**, 17–32.

Gephart, R. (1993). 'The textual approach: risk and blame in disaster sensemaking', *Academy of Management Journal*, **6**, 1465–1514.

Gephart, R. and Pitter, R. (1993). 'The organizational basis of industrial accidents in Canada', *Journal of Management Inquiry*, **3**, 238–252.

Gephart, R. and Pitter, R. (1995). 'Textual analysis in technology research', *Technology Studies*, **2**, 325–356.

Glaser, B. and Strauss, A. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Aldine, Chicago.

Hesse-Biber, S. and Dupuis, P. (1995). 'Hypothesis testing in computer-aided qualitative data analysis'. In: Kelle, U. (Ed.) *Computer-Aided Qualitative Data Analysis*, Sage, Newbury Park, CA, pp. 129–135.

Huber, G. (1995). 'Qualitative hypothesis examination and theory building'. In: Kelle, U. (Ed.) *Computer-Aided Qualitative Data Analysis*, Sage, Newbury Park, CA, pp. 136–151.

Kabanoff, B. and Holt, J. (1996). 'Changes in the espoused values of Australian organizations 1986–1990', *Journal of Organizational Behavior*, **17**, 201–219.

Kelle, U. (1995). 'Introduction: an overview of computer-aided methods in qualitative research'. In: Kelle, U. (Ed.) *Computer-Aided Qualitative Data Analysis*, Sage, Newbury Park, CA, pp. 1–17.

Kuckartz, U. (1995). 'Case-oriented quantification'. In: Kelle, U. (Ed.) *Computer-Aided Qualitative Data Analysis*, Sage, Newbury Park, CA, pp. 158–166.

Lee, A. S. (1991). 'Integrating positivist and interpretive approaches to organizational research', *Organization Science*, **4**, 342–365.

Leiter, K. (1980). *A Primer on Ethnomethodology*, Oxford University Press, New York.

Lonkilla, M. (1995). 'Grounded theory as an emerging paradigm for computer-assisted qualitative data analysis'. In: Kelle, U. (Ed.) *Computer-Aided Qualitative Data Analysis*, Sage, Newbury Park, CA, pp. 41–51.

Marcus, G. and Fischer, M. (1986). *Anthropology as Cultural Critique: an Experimental Moment in the Human Sciences*. University of Chicago Press, Chicago.

Pawson, R. (1988). *A Measure for Measures: a Manifesto for Empirical Sociology*, Routledge, London.

Perin, C. (1995). 'Organizations as contexts: implications for safety science and practice', *Industrial and Environmental Crisis Quarterly*, **9**, 152–174.

Prein, G. and Kuckartz, U. (1995). 'Introduction: Between quality and quantity'. In: Kelle, U. (Ed.) *Computer-Aided Qualitative Data Analysis*, Sage, Newbury Park, CA, pp. 152–157.

Random House, 1968. The Random House Dictionary of the English Language, College Editor. Random House, Inc., New York.

Richards, T. J. and Richards, L. (1994). 'Using computers in qualitative research'. In: Denzin, N. K. and Lincoln, Y. S. (Eds) *Handbook of Qualitative Research*, Sage, Thousand Oaks, CA, pp. 445–462.

Rifkin, W. E. (1994). 'Who need not be heard: deciding who is not an expert', *Technology Studies*, **1**, 60–96.

Roller, E., Mathes, R. and Eckert, T. (1995). 'Hermeneutic-classificatory content analysis: a technique combining principles of quantitative and qualitative research'. In: Kelle, U. (Ed.) *Computer-Aided Qualitative Data Analysis*, Sage, Newbury Park, CA, pp. 167–178.

Schutz, A. (1973). 'Concept and theory formation in the social sciences'. In: Natanson, M. (Ed.) *Collected Papers I: The Problem of Social Reality*, Martinus Nijhoff, The Hague, Netherlands, pp. 48–66.

Seidel, J. and Kelle, U. (1995). 'Different functions of coding in the analysis of textual data'. In: Kelle, U. (Ed.) *Computer-Aided Qualitative Data Analysis*, Sage, Newbury Park, CA, pp. 52–61.

Sibert, E. and Shelly, A. (1995). 'Using logic programming for hypothesis generation and refinement'. In: Kelle, U. (Ed.) *Computer-Aided Qualitative Data Analysis*, Sage, Newbury Park, CA, pp. 112–128.

Smith, R. (no date). 'The toxicology of hydrogen sulphide with particular reference to the effects of long-term, low-level exposure'. Dartmouth Medical School, Hanover, NH.

Starbuck, W. H. and Mezias, J. M. (1996). 'Opening Pandora's box: studying the accuracy of managers' perceptions', *Journal of Organizational Behavior*, **17**, 99–117.

Tallerico, M. (1992). 'Applications of qualitative analysis software: a view from the field', *Qualitative Sociology*, **14**, 275–285.

Tesch, R. (1991). 'Introduction: Computers and Qualitative Data II', *Qualitative Sociology*, **14**, 225–243.

Weick, K. (1990). 'The vulnerable system: analysis of the Tenerife air disaster', *Journal of Management*, **16**, 571–593.

Weick, K. (1993). 'The collapse of sensemaking in organizations: the Mann Gulch disaster', *Administrative Science Quarterly*, **38**, 428–452.

Weick, K. (1995). *Sensemaking in Organizations*, Sage, Thousand Oaks, CA.

Weick, K. and Roberts, K. H. (1993). 'Collective mind in organizations: Heedful interrelating on flight decks', *Administrative Science Quarterly*, **38**, 357–381.

Wolfe, R., Gephart, R. P. and Johnson, T. (1993). 'Computer facilitated qualitative data analysis: potential contributions to management research', *Journal of Management*, **19**, 637–660.

