THE APPLICABILITY OF ARISTOTLE'S *RHETORIC* IN TECHNICAL COMMUNICATION

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B.A., Winthrop College, 1985

A REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF ARTS

Department of English

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1987

Approved by:

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IN TECHNICAL COMMUNICATION

Rhetoric in a Scientific World

We live in a world dominated by scientific knowledge and technology. It would seem that the technology with which we live has made anything that does not fit neatly within its boundaries obsolete, or at least suspect. Some might agree with Halloran, who goes so far as to say, "As a source of knowledge and value pertinent to the conduct of life, art has been declared null" (623). However, there is increasing recognition in such areas as technical communication of the value of "non-scientific" rhetorical strategies in communication. It appears that those who deal with scientific data, specifically those who communicate values and opinions based on the data, are turning to the theories of ancient rhetoric as bases for technical communication (Whitburn 226).

One possible reason for this shift in interest is that we are beginning to realize that simply presenting data is not necessarily communication. We turn to the ancient rhetoricians because they "were realistic enough to recognize that men are creatures of passion and of will as well as of intellect. We have to deal with men as they are, not as they should be" (Corbett 93). Another reason that we may be looking to the past as a source in technical communication is that we are simply coming to realize that in technical communication we use many of the theories put forward by the early rhetoricians.

The break between art and science was evident by the mid-seventeenth century. As the scientific revolution ushered itself in, there was a great interest in scientific phenomena. Aristotle did not fit with the mood of the period because he dealt with what James McCosh labelled "perfected Universal Logic," while the men of the times dealt with "particular logic" (Howell 415). The assumption of the period was that there was knowledge in the specific, rather than the general, fact. Man was fallible; science was not. There was no "common place of knowledge" within scientific knowledge. Science existed outside of man, while Aristotle spoke of "artistic proof" as that which is other than the specific data which one brings to an argument. As men became swept away with the scientific revolution, they no longer trusted themselves as sources for knowledge. It was simpler to record data than to make speculation on it. The fact proven by science was the "hobby horse" men generally rode.

The twentieth century, with its advances, has been much like another scientific revolution. We are beginning to realize that part of the scientific community "is interested in facts or instances as illustrations of some theory or point of view" (Campbell 391). However, not all scientists are favorably disposed to the idea that scientific data is not an end-all, the idea that man assigns significance and implications to the scientific data after it has been recorded. Technical communication, some might state, should be nothing more than an impersonal relaying of scientific and technical data. And there are many who find room for art in neither science nor technical communication. Wilbur S. Howell, in a footnote in his Eighteenth-Century British Logic and Rhetoric, writes:

> Edward P. J. Corbett's Classical Rhetoric for the Modern Student (New York, 1965), pp. 94-142, attempts to make the ancient theory of topics available to speakers and writers of the twentieth century. It is unfortunate, however, that Mr. Corbett should have presented this theory without having explained that rhetoricians of the seventeenth and eighteenth centuries gave it such a critical rejection as to make it obsolete, and that rhetoric should not accept it today without proclaiming it an aid only to the slow and dull. (443)

As well as commenting on eighteenth century theories of rhetoric, Howell speculates as to what the rhetoric of the twentieth century should be when he writes:

> In the view of the authors whom De Quincey ignored, rhetoric in a culture permeated by the standards of scientific and scholarly proof must become scientific and scholarly itself, and must argue from the facts of the case, not from suppositions that may represent mere

popular misconceptions and prejudices. (443)

"The history of rhetoric since the seventeenth century," writes Booth, "could be described as a mounting suspicion and final rejection of ethical and emotional proof and then a progressive narrowing of the range of what is accepted as substantive proof" (144-5). Ironically, even as part of the scientific community has been coming to terms with the usefulness of ancient rhetorical theories in its communications, some, generally those not actively involved in technical communication, are discrediting the theories. They assume that scientific research, in and of itself, has an innate value. Actually, scientific research, taken objectively, has no value (Whitburn 232). When the research is communicated, however, it goes beyond the barrier of impersonality; it is given a value, an interpretation.

Many would say that we live in a world of specialized knowledge, with which I would not disagree. What happens, however, when we wish to "escape," to go beyond our specialized knowledge and communicate with those around us? Is it not possible because we have become a "specialized society"? Of course not; when we want to meet beyond our specialization, we find some common grounds for communication. By thinking that there is no use for ancient rhetoric in a specialized society, we become blind to reality, the conditions that our specializations imply and we as a community agree upon. We may continue to stumble through this situation, being "specialized" one moment and communicating with another type of specialist the next. In doing so, Murphy writes, "we repress the fact that even in technologically advanced countries important decisions are often made even on the basis of such general principles (as more and less, past and future fact, and possible and impossible)" (49).

There are those who believe that there is no room for the "human factor," for an "emphasis on style" as well as on information in technical communication. This view persists, even in the face of current technical theories of technical communication, "at least in part, because analysts of technical discourse, as opposed to technical discoursers, have since the seventeenth century ignored their own self-contradictions" (Childs 65). The analyst of technical discourse may be unaware of anything other than the data which is in a communication. The discourser, however, knows that technical communication involves more than simply recording and repeating data. Technical communicators do, whether knowingly or not, follow many of the rules set forth by ancient rhetoricians. I agree with those who find rhetoric a tool in effective technical communication and will, in this paper, argue that there is, within successful technical communication, a use for many of the theories put forth by Aristotle in his Rhetoric.

Aristotelian Persuasion in Technical Communication

To consider whether Aristotle's Rhetoric should be of any value in technical communication we must consider whether technical communication itself uses rhetoric. In using "rhetoric," we will not use the commonly misapplied definition which is "persuasion." For the purposes of this report, we shall return to Aristotle's definition. Rhetoric is a faculty for providing persuasion; it is "an art, the function of which is not [absolutely] to persuade, but to discover the available means of persuasion in a given case" (6). It is not simple persuasion; it is an art through which one can discover how to persuade when necessary in a given situation. Rhetoric "has to do with common knowledge. . . things that do not belong to any one science" (1). This is perhaps one reason why some in science find fault with Aristotle's definition. They assume that he is implying that persuasion is accomplished through means other than presentation of scientific data. This is not what Aristotle writes. His definition does make a division between science and "common knowledge." He does not, however, write that persuasion is possible in any particular situation without scientific data. The fact that Aristotle does see a difference between science and art is quite interesting. He sees that two equally divisible units, which appear to have nothing in common, come together in communication. No one would deny the break between the two. Actual persuasion, however, the type which is used in technical communication, is a combination of rhetoric and scientific data.

The presentation of data is definitely part of the persuasion in technical communication. It is not, however, the only part. Aristotle saw that mere presentation of data will not always sway. The Rhetoric is a text which offers "artistic" methods for persuasion. Many powerful forms of persuasion exist outside of the realm of scientific gathering and reporting of valueless information. I do not believe that technical communication is a simple presentation of scientific and technical data. The data are some of the means to a specific end, towards persuasion. This becomes apparent when we turn our attention to what the aims of technical communication actually are.

Technical communication, by its own name, implies that there is a relay of scientific and technical data. Also, by its own name, technical communication "communicates," exchanges ideas and values that are directly tied to the data. The name seems a contradiction; it combines technology with art. It does not simply present data. Technical communication, by definition, is that which meets three specific criteria set up by those who create and teach it:

> 1. Technical Communication deals with a problem or subject matter that is not popular knowledge but, rather, is specialized in that it belongs to art, science, medicine, engineering, or the like.
>
> 2. Technical communication is the product of study, investigation, observation, analysis, and measurement to obtain accurate and precise information about the problem

or subject matter.

> 3. Technical communication presents the information thus gained so that it will be clear and meaningful to the person or persons for whom it is intended. (Houp 4)

It does use the data to make inferences, speculations, conclusions, and recommendations. This definition of technical communication also implies that there is persuasion, in that, in technical communication one presents data and states, "This is what I infer. The data leads me to believe X." The scientists or engineers who create technical communication must take on roles different from their usual jobs as "data gatherers." They must be communicators who persuade. This is why, often, a technical communication is created by two or more people; one person records the data and offers implications while the other makes clear the information. There are three tasks that technical communicators must accomplish in order to effectively relay information: (1) they must acquire information, which no scientist would deny; (2) they must make it usable for a specific audience[1], which some might deny; and (3) they must transmit it successfully (Whitburn 227). Effective communicators do this; ineffective communicators do not. Campbell writes that technical communication must be rhetorical because a "nonrhetorical stance would hold no points of view and make all

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[1] I would add to Whitburn's tasks that of making the data usable to a specific situation as well as audience.

facts and instances equally significant. This, science does not do" (230). Data, taken at face value, with no supposed implications or value judgements is of no use. I do not believe that technical communicators see no persuasion in their discourse. And, anyone who successfully attempts to persuade must, whether realizing it or not, make use of rhetoric. Some might say, "If one can use the art of rhetoric without knowing that it is rhetoric, per se, why bother learning about rhetoric?"

If rhetoric is an essential tool to persuasion, as I feel it is, and technical communication's aim is persuasion, which I feel it is, then a fuller knowledge of rhetoric could sharpen skills necessary for technical communication. Whitburn writes that "the ideal communicator embodies the complete set of rhetorical approaches, grasps the whole communication situation and is free to use judgement to create ideal coherence" (228). One who understands Aristotle's theories on rhetoric will be more aware of possible methods of persuasion in a given situation than one who does not.

Some might argue that technical communicators write only for scientists or other specialists. This is simply not true. Much of the discourse which falls under the heading of "technical communication" deals directly with people, not with ranked specialists. Technical communicators do far too many things for us to limit the scope of their communication to interaction between two or more specialists. Technical communicators may create operations manuals for employees. They might conduct feasibility studies for management or make proposals to a group which might very well consist of people with quite dissimilar scientific backgrounds. Technical communicators also may write a set of usage instructions, again not simply for a specialist. Aristotle writes that rhetoric "is suited to popular audiences, since they cannot follow scientific demonstration" (xxxvii). This "popular audience" does not mean an "ignorant" group; it simply means a group without the background of the communicator. Technical communication must be accessible to "common people" as well as to specialists. Because the audience is not necessarily made up of specialists, a technical communication must attend to the medium as well as the message. The technical communicator must take every opportunity to involve the audience. An uninvolved audience will not heed even the most sound advice.

Technical communication cannot simply present data on the assumption that the reader, which Aristotle rightly calls the "judge," will have the same knowledge and make the same assumptions. There must be a tie, a bridge between scientific data and artistic persuasion in technical communication. Otherwise, the discourse will be "impossibly rigid and dehumanized" (Childs 67).

The ultimate goal of technical communication is not as easy as simple persuasion (if there is such a thing as "simple persuasion"). It is persuasion specific to audience and situation. The technical communicator is an advisor. If the communication is not persuasive, the judge will reject it. It is that simple.

Those who created the "Independent Test Observer Team Report to the Presidential Commission on the Space Shuttle Challenger Accident" (presented in its entirety in Appendix A), I imagine most would agree, presented a form of technical communication. It conforms to the criteria set up for technical communication in that it deals with a specialized problem. The report is an "investigation of the Space Shuttle Mission 51-L accident by determining if the tests and analyses being performed by the Marshall Space Flight Center (MSFC) and Morton Thiokol, Incorporated (MTI) were adequate to provide the information needed by the panel" (1). Also, the technical communicators present the information in a precise manner in such sections as "Test Evaluations" and "Analyses." The report is clear in its presentation of information; after presenting the data, the discoursers have a list of conclusions which stem logically from the data. In the section of conclusions drawn from data presented earlier appears:

> 4. Tests and analyses performed indicated that putty holding pressure, thereby delaying O-ring pressurization; low temperature adversely affecting O-ring resiliency; ice unseating the secondary O-ring; case diameter mismatch, resulting in near metal-to-metal contact, producing excessive squeeze that delays or prevents pressure-assisted actuation of the O-ring; and assembly

damage could contribute to seal leakage. (12)

Also, after the data and conclusions, there is a section entitled "Recommendations" where the discoursers give their views on the implications of the data and conclusions. From this section, for example, appears: "3. Better O-ring quality is needed, especially in the areas of avoiding twist in splicing, inspecting for inclusions, and pedigree" (13).

The writers are giving advice. They are persuading readers that "The O-ring's quality is unacceptable." This is the nature of technical communication; it presents technical data, makes conclusions, and attempts to move the reader to a specific point of view.

If technical communication does aim to persuade, the "persuasive utterance is realized in some decision" (Aristotle 14). If one is to persuade, if one is to state, "We should do X," he must be in control of situation as well as data. "Aristotle's rhetorician is a person who examines the situation and uses the art to make an inventory of the possibilities" (Murphy 25-6). The ideal technical communicators also must have an ability to analyze and make inventory of the communication possibilities for a given situation. They must, as Aristotle suggests, "have a real knowledge of the facts" (157). This means a knowledge of the specific situation and audience calling for that communication. Another thing that technical communicators must do that Aristotle also wrote of effective orators is to "state [their] case and then prove it" (220). Now that we have considered in what ways technical communication is persuasion and pointed out how one who practices the communication should be aware of the methods of persuasion, we will turn specifically to the three aspects of Aristotelian rhetoric which are particularly relevant to technical communication.

Technical Communication as Deliberation

There were in Aristotle's mind three branches of rhetoric in which to state and prove a case. They included the forensic, deliberative and epideictic branches. The forensic branch dealt with past occurrences and was usually used in the courtroom. Its aim was to consider guilt and innocence in a specific situation. The deliberative branch involved matters of government or anything upon which it was necessary to advise. The epideictic branch covered most other forms and situations which called for rhetoric. Its aim was praise or blame.

I believe that technical communication is most similar to the deliberative branch of Aristotle's rhetoric. "The deliberative branch involves speeches of counsel or advice—as political speeches addressed to an assembly or to the public on questions of state, but also, for example, a speech addressed to an individual (a ruler, or, indeed, any person who is to be advised)" (17). This is the nature of technical discourse; it takes data, makes value judgements and gives advice. The technical communicator recommends, "gives encouragement," or rejects, and therefore "dissuades" (Aristotle 17). The aim of the deliberative speaker concerns advantage, injury and expediency (Aristotle 18-9). Aristotle's deliberative speaker gives advice only about the future (17). Some would argue that this is not the case for technical communication. They might cite, for example, the reports after the shuttle disaster. "The reports dealt with the past," they might conjecture. The data did deal with the past. The data in all technical reports, for that matter, comes from previous experiments and investigations. The gathered information is then used to project an opinion or viewpoint into the future. There were two types of reports after the shuttle disaster. One was conducted to see who was responsible for the "mechanical malfunction." This would be what Aristotle labeled the "forensic" branch of rhetoric, which was used to prove innocence or guilt. The other type of report created after the disaster, like the one in the document in the Appendix, made its end the discovery of the mechanical problem. The reports dealing with the disaster as a framework against which future launches would be checked were like the deliberative oration in that they were not interested in deliberating over the ends of the research. That was established. The ends of both technical communication and the deliberative branch are, "what is good, advantageous, expedient or useful" (Corbett 146).

The end of the persuasion in the Appendix was to ensure that the tests conducted adequately measure the cause of the shuttle disaster. The means to the end, however, were open to deliberation. When it appeared that there was more than one way to set forth to the end, then the technical communicators considered which of these would be easiest and most effective (Aristotle Ethics 70). In fact, the communicators could not agree on whether the data actually warranted making recommendations or not. Because they could not agree, they were forced to give a final note after their recommendations:

> VII. Additional Comments
>
> Several members of the team (Haberman, Kennedy, and Wells) have strong recommendations for what should be included in additional tests. The remaining members of the team (Dufka, and Marx) believe that specific test recommendations are not warranted and should not be included in this report. (13-14)

The technical communicators were divided on what action the audience should take to ensure that the tests were adequate.

In technical communication, as well as in deliberative speaking, the communicators want the audience to choose something for their happiness or to simply avoid something to continue in happiness (Aristotle, Ethics 148). Technical communication often is communication about alternatives. Though the end is clear, the means to that end are open to debate. If there is no alternative, there is no need for presenting the information in order to persuade. "On matters which admit no alternative, which necessarily were, or are, or will be, or are, certainties, no one deliberates, at least not on that supposition--for nothing is to be gained by it" (Aristotle 15). Much is gained from deliberation; much is also gained from considering alternate points of view.

The technical communicator should take note of Aristotle's theories on how the deliberative speaker must refute arguments against his position. Aristotle says that deliberative speakers "meet opposing arguments by direct refutation or by pulling them to pieces in advance" (235). The technical communicator, much like the deliberative speaker, should consider and counteract any possible arguments that might be raised against the persuasion.

In the example report, because the communicators were considering tests done by others, they had to conclusively present any findings contradictory to the results gathered by MTI and MSFC. There could be no opportunity for argument against their findings:

> Among these tests, resiliency characterization is by far the most comprehensive test, and the results clearly indicated the slow rebound response of the O-rings at cold temperatures. The test results, therefore, support the O-ring actuation time delayed by the low temperature failure mechanism. (4-5)

The deliberative speaker and the technical communicator must be willing to make some concessions, but not make them in their aims. (Aristotle 18). Both types of communicators must be objective, yet firm in their presentations and persuasions.

Artistic Persuasion in Technical Communication

If technical communication uses rhetoric, Aristotle's definition of the term, it follows that technical communication uses artistic proofs. Artistic proofs "are those furnished by rhetoric through our own efforts. Non-artistic proofs are those not supplied by our own efforts, but previously existed" (8). A rhetorical proof is not the same thing as a scientific proof (5). The scientific data upon which a persuasion is based would be the "non-artistic" proof. Anything, then, appearing in the argument proper other than the scientific data would fall under the realm of artistic proof. This, again, is based on the assumption we made earlier that technical communication is not simply a reporting of scientific data; it is an assessing of data for the purpose of presenting viewpoints and making implications.

The rhetorical modes of artistic proof that Aristotle makes note of include induction (example) and syllogism (enthymeme) (10). Aristotle writes that "arguments from enthymeme are more applauded" (11). However, because artistic proofs are less valued than inartistic proofs by moderns, they find no need for rhetoric in technical communication. I would suggest, however, that technical communication makes use of both example and enthymeme in persuading. Before I discuss the enthymeme in technical communication, however, I shall consider the inductive method of persuasion, the example, as it appears in technical communication.

Though Aristotle writes that the enthymeme is "in general, the most effective among the various forms of persuasion" (5), he also writes that "Argument from example is best suited to deliberative speaking" (149). Though example is inartistic, inference from example is an artistic proof. In our example report, the communicators use example in showing how inferior the quality of O-ring production is:

> In one instance, traceability of one group of O-rings to the parent material's source and lot was completely lost by the supplier. Parts or materials of unknown pedigree therefore apparently were accepted for critical application. (5-6)

The example clearly leads the audience to the inference that O-ring production is not acceptable. An inference made from example is how technical communication generally persuades.

Examples aid in the communicator's chain of logic; they are not, however, the only aid in persuasion. Enthymeme also appears in technical communication. The forms of enthymeme Aristotle considers are the sign and probability. For example, one may move to a universally accepted statement such as "She has a child" from the specific, verifiable statement, "She is in milk" (Aristotle 14). The data in a technical communication leads to a conclusion based on that data. The sign in technical communication, the specific point, leads, irrefutably, to a universally accepted point. Once the specific point has been made clear and been accepted, the audience will be able to supply the generally accepted conclusion to which it leads. In our example, the specific point, "The colder the temperature, the longer blow through was delayed, possibly holding pressure off the primary O-ring long enough for joint rotation to occur" (7), leads to an assumption:

> 4. Tests and analyses performed indicated that putty holding pressure, thereby delaying O-ring pressurization; low temperature adversely affecting O-ring resiliency; ice unseating the secondary O-ring; case diameter mismatch, resulting in near metal-to-metal contact, producing excessive squeeze that delays or prevent pressure-assisted actuation of the O-ring; and assembly damage could contribute to seal leakage. (12)

The conclusion is accepted on the premise that the specific fact is true. If the fact is proven incorrect, the assumption is discarded. A new assumption will stem from the data that invalidates the previous assumption.

In technical communication the discourser presents a specific point of view to the audience. If the audience clearly receives the specific points and conclusions, they will bring themselves to the communicator's recommendation. There should be no surprise in technical communication (Bitzer 407). Technical communication consists of a chain of logic whose links lead, necessarily, to a specific conclusion or point of view. This enthymeme is set aside as an entire section entitled "Conclusions" and "Recommendations" in many technical reports. The data, which are usually recorded separately from the conclusions and recommendations, might appear in a section entitled "Discussion," and lead to conclusions. The conclusions, generally stated in simple sentences, lead to a specific recommendation. If the recommendation, which is generally presented last, is a surprise to the reader, then either the chain of logic from data through the conclusions is not clear, or the conclusions simply do not work towards the correct recommendation. The report, for example, presents no surprise in its recommendations; the data and conclusions lead to this view point:

> V. Conclusions
>
> The review of Tests and Analyses conducted at MSFC and MTI led us to the following conclusions:
>
> 1. Inadequate quality control procedures for determining O-ring quality was indicated.
>
> 2. Insufficient analysis was performed for partial joint rupture emanating from all sources of preexistent cracks.
>
> 3. Adequate analyses and tests have been conducted to indicate that SRM inhibitor flaws, propellant debonds adjacent to the joint, leak check port leaks, and case membranes rupture from a preexisting crack are unlikely sources for burn through in the SRM.
>
> 4. Tests and analyses performed indicated that putty

holding pressure, thereby delaying O-ring pressurization; low temperature adversely affecting O-ring resiliency; ice unseating the secondary O-ring; case diameter mismatch, resulting in near metal-to-metal contact, producing excessive squeeze that delays or prevent pressure-assisted actuation of the O-ring; and assembly damage could contribute to seal leakage.

5. Testing and analysis were performed which only approximate the operation of the full-scale joint and possible leaking mechanisms. Therefore, some caution is needed in projecting the operation of small-scale tests to full-scale hardware. In fact, it is apparent the operation of the full-scale joint and its leaking mechanisms is not fully understood.

6. Tests appear to support that a slow leak or a leak which becomes plugged by combustion products and soot can occur. Analysis indicates that a delay burn through is possible as a result of a slow leak or a leak that stops and later resumes.

7. Tests and analyses need further correlation.

8. In general, the results of the tests and analyses performed were interpreted properly, and the data was used correctly. (12-13)

VI. Recommendations

1. If it is necessary to obtain more information regarding the leakage mechanisms of the SRM joint, we recommend that full-scale, full-diameter testing of the SRM joint be performed.

2. A more in-depth analysis for partial joint rupture emanating from all sources of preexistent cracking in the joint should be done.

3. Better O-ring quality control is needed, especially in the areas of avoiding twist in splicing, inspecting for inclusions, and pedigree.

4. Correlation of analyses and test results should continue.

The recommendations that the technical communicators suggest should come as no surprise to those who have carefully read the report. Each of the recommendations is the probable ending point for the specific information given in the data and conclusions. The logic that works throughout a technical report is simple; specific fact + assumption lead to the probable, a generally accepted inference. The specific logical equations included in our example report include:

Data + Conclusion #5 = Recommendation #1

Data + Conclusion #3 = Recommendation #2

Data + Conclusion #1 = Recommendation #3

Data + Conclusion #7 = Recommendation #4

Each of the recommendations is an extended assumption. The movement from data to assumption to further inference which occurs in technical communication is the nature of Aristotle's enthymeme (10). Many of the specific conclusions, however, do not end in discussion. This is simply because there is no need to advise on them. Conclusion #8, "In general, the results of the tests and analyses performed were interpreted properly, and the data was used correctly," for example, need not end in a recommendation. The interesting thing about this conclusion not ending in a recommendation is that it is the answer for the panel's actual appointment. The team answers its inital question and offers unsolicited advice. In the communication, specific conclusions, parts of the syllogism, may be disputed. (Murphy 28). The persuasion itself, the recommendations, will not easily be disputed if the chain of logic is well constructed.

Also, if the chain of logic is to be well constructed, the technical communicator must choose to present information in a format with which the audience is familiar. For example, one would not present conclusions, then recommendations, only to be followed by the initial data. There is a specific order for presenting technical information. In the same sense, a technical communicator must persuade following "general avenues," using common topics such as cause and effect or situation and consequence, with which the audience is familiar. In the method of relaying data and implications, there should be no surprises.

In the Rhetoric Aristotle lists several topoi, common places or lines of argument. Some may imagine that technical communication pays no heed to the topoi in the persuasion process. Whether they realize it or not, technical communicators do use common lines, common ways of presenting their points in order to move the audience to a verification of conclusions and recommendations.

Though not all twenty-eight of the topoi can pertain to technical communication, many of the topoi are used in current technical communication. Many communicators use existing decisions in persuasion (Aristotle 165). They use a generally accepted decision to make a point and therefore persuade. In our example report, for example, we find:

> Inspection of O-rings for inclusions has revealed high density metallic slivers and particles of iron oxide, silica, and calcium salts. Acceptance specification STW-7-2875 prohibits acceptance of hard white inclusions over 0.010-inch diameter, all visible black inclusions, and metallic inclusions of any size. (5)

The communicators use this decision, STW-7-2875, to lead, eventually to a conclusion and recommendation for better O-ring quality control. If the audience accepts the specifications they will make the same inferences and come to the same recommendation as the communicators.

Another of the topoi that Aristotle suggests is persuasion by means of consequence (Aristotle 166). The communicator may perhaps persuade that the consequences which result from a certain practice are against the best interests of the audience. The example report again persuades for better O-ring quality control through the presentation of possible consequence:

> Splicing (of the O-ring) is carried out on a proprietary process, which precludes positive control to assure that changes that may require requalification are not introduced without approval by a customer. There is no requirement in the controlling documents that precludes splicing in a permanent twist that could distort the O-ring in its groove, nor is there an inspection procedure at MTI to detect a built-in twist. (5)

Those on the team were concerned with the consequences caused from a lack of restrictions on the production of O-rings. A twisted O-ring could cause another "accident" like that of the Challenger. Certainly this would cause the audience to acknowledge the need for greater O-ring control.

Behind their recommendation for more full-scale testing, the observer team cites a conflict of data (Aristotle 169):

> In an attempt to characterize joint performance, several tests were carried out. Among these, the most significant tests were the O-Ring Blow-by Dynamic Test, the Discrete Increment Piston Cone Test and the Ice in Joint Test. The O-Ring Blow-by Dynamic Test simulated the full scale joint rotation, pressurization rate, and O-ring cross section (0.280-inch diameter) but was

sub-scale with respect to the diameter of the joint. (6)

The tests were done on a smaller scale that could present imprecise information for full-scale use. This is an important conclusion to the team. It appears again in the final note of the report.

Various Appeals in Technical Communication

Throughout the report, in the summary as well as in the final note, the observation team keeps with its objective logic while not ignoring the emotional implications tied to their general persuasion. Whitburn writes that "What is needed (in technical communication) are rhetorical approaches to shape a persona that makes vivid appeals to the stress and subtle appeals to the emotions" (244). Many of the rhetorical approaches which can shape a persona in technical communication are available in Aristotle's theories. The three means of persuasion which are provided by the speech itself include ethos, emotion of the audience, and the logic of the argument proper (8). "It follows that the speaker who communicates his intelligence, character, and good will to his audience has the confidence of his hearers" (Aristotle 92). This is as true for the technical communicator today as it was for the orator of Aristotle's time.

"The ethical appeal can actually be the most effective form of persuasion" (Corbett 93). This is definitely true also in technical communication. "Ethos," writes Aristotle, "is determined by the quality of the purpose. The quality of the purpose is determined by its end" (230). In technical communication, quality is not determined by the underlying data; it is determined by the implications and recommendations which proceed from it. It is the "moral character" of the communication.

If scientific data is all that technical communication presents, there is no moral character in the communication (230). In our example report the team members are obviously interested in the presentation of data. That was not, however, their only concern. If it were, the team would have not attempted to involve the audience in the actual discovery of data. Take for example, this explanation of the team's approach to the situation:

> The team took a step-by-step approach to observing the tests and analyses being performed. The initial steps were an overview of the activities at MTI and MSFC and a review of how each possible leak mechanism presented by NASA related to the SRM joint and the O-ring was supported by specific tests and analyses. We then looked at each test and analysis to assess its objectives, approaches, and results; the interpretation of these results and the conclusions drawn; the relationship between specific tests and analyses; and the adequacy of the information provided to evaluate the proposed leakage mechanisms. Finally, we summarized our observations, reached conclusions and made recommendations to the Commission's Accident Analysis Panel. (3-4)

The communicators choose to involve the audience with the use of "we." An audience will have a better impression of the logic, as well as of the communicator, if they feel involved. "The communicator must give the best impression of himself and get the judge to the right state of mind. This is true, above all, in deliberative speaking" (Aristotle 91). The technical communicator must show the audience that their best interests are at the heart of the communication. This must pervade the work; if not, the audience may discard the appeals and simply discard the advice (Corbett 95).

One thing that a technical communicator must establish early in the communication is the sense of ethos. The audience must see that the communicator is worthy of making conclusions and assumptions resulting in recommendations. Many technical reports simply begin with a section which lists the credentials of those doing the report. Our example report includes this information before the data on approach and findings:

> B. Organization
>
> The members of the team and their affiliations are:

Eugene G. Haberman (Chairman)	Air Force Rocket Propulsion Laboratory
Mohan Answani	The Aerospace Corporation
Laddie E. Dufka	The Aerospace Corporation
Don E. Kennedy	TRW

Michael L. Marx	National Transporation Safety Board
Wilbur W. Wells	Air Force Rocket Propulsion

(3)

This gives direct evidence that those who are presenting the information are authorities. The audience assumes that this team would be capable of objectively considering the task before them. This listing of affiliations is also helpful when considering the final "Additional Comments":

> Several of the team (Haberman, Kennedy, and Wells) have strong recommendations for what should be included in additional tests. The remaining members of the team (Dufka, and Marx) believe that specific test recommendations are not warranted and should not be included in this report. (13-14)

The audience may consider the additional recommendations worthwhile because three members suggest them. They might also consider that one of those against the recommendations, Marx, whose affiliation is with the National Transportation Safety Board, may not be as much of an authority as those who make the recommendations. Once the audience is aware that the authors have a background which would qualify discussion on the topic, the communicator must take care to address the audience on its emotional level.

It would not do in technical communication to simply relay data and make recommendations. Technical communicators must explain the situation, must explain why the implications are significant and why the recommendation is necessary. Technical communicators meet the audience, at least in theory, on a human, emotional level. Certainly objective data is no emotional meetingplace for human communication. Therefore, the technical communicator must keep in mind the opinions of the audience (Aristotle 156). The orator must deal with an audience and an audience is necessarily emotional (Aristotle 3-4). The technical communicator must make it clear in the presentation that the recommendation is in the audience's best interest. To do this, the technical communicator must make clear the problem on a level that will make the audience think, "This is a problem" and present the recommendation in such a way that the audience says, "This is the best solution to the problem." The sample communication had no problem incorporating emotion simply because of its topic. Almost anyone who could have been the audience would have realized the implications of the research. Most would recognize a need to check the research of MTI and MSFC.

The observation team dispenses with their task rather easily in a conclusion: "In general, the results of the tests and analyses performed were interpreted properly, and the data was used correctly" (13). There is no need for a recommendation in this situation; the initial questions are answered. The observation team does not end its report here, however. The committee continues to offer unsolicited recommendations. Because it is not part of their original purpose as a committee, the team must appeal to the emotions of the audience to ensure that they will consider the additional information in the report. In the list of conclusions, as well as in the summary, the communicators make reference to the sub-standard tests. In a conclusion, the team appeals to audience for full-scale testing: "In fact, it is apparent the operation of the full-scale joint and its leaking mechanisms is not fully understood" (12-13). Surely the audience will consider this conclusion and recommendation simply because of the wording; "in fact . . . . . is not fully understood." Persuading the audience through artistic proof is vital to technical communication; knowing what to say gives the data implications which lead to an agreeing audience. It is not, however, all that the technical communicator must consider; "one must also know how to say it" (Aristotle 182). The technical communicator's success is as equally attributable to style as it is to the clear presentation of data and the concentration on artistic proof.

Style in Technical Communication

Aristotle's Rhetoric has a great deal of stylistic advice to offer technical communicators. Technical communication, because it is generally considered a simple relaying of data, is thought to be impersonal. Fortunately, those who think technical communication is without style are not those who create it. Most technical communicators realize that "extremely impersonal communication impedes comprehension" (Childs 67, note 7). In order to involve the judges in the decision making process, and thereby move them to the intended recommendation, the technical communicator must make the report "accessible." The two virtues of style that technical communicators try to incorporate in their work are "clarity and appropriateness" (Murphy 61). These are also the two virtues that Aristotle extols in the Rhetoric.

A good style, writes Aristotle, "is clear" (185). The effective communicator should "avoid ambiguity" and "use specific terms" whenever possible (194). One suggestion that Aristotle makes towards this end is to "describe an object instead of naming it" (96). Technical communicators always must consider that the final viewer of their communication may not have a technical background. Therefore, they should always define, describe or explain any scientific or technical considerations in the persuasion. This ensures that the communication is appropriate for the audience. In our report, the communicators try to make the test results accessible to a non-scientific audience:

> The 5-inch-diameter hot-firing motor tests were conducted to get preliminary data for O-ring response to various defects and to develop design data for the 70-pound (propellant) hot-firing motor. Hence, while the motor operated at high-pressure and high-temperature conditions it was configured with only one O-ring and did not represent the true motor geometry. Qualitative data indicated that an O-ring joint can sustain leakage

> without an immediate burn through. (8)

This, honestly, is the biggest failure with our example report. The tests and results are presented. They would be much more accessible, however, and therefore more effective if they were described. The audience must consider the report's conclusions and recommendations without a clear understanding of the data which form the basis of the report. The style seems inappropriate.

Also on the topic of appropriateness, Aristotle writes that the treatment of the subject, as well as the language, must be appropriate. The presentation should be in proportion to the subject (197). There is in our report, for example, more detail to the data, its conclusions and recommendations. The conclusions and recommendations are actually mentioned twice. They appear once in the summary and once in their own sections. The charter for the group, on the other hand, doesn't receive too much attention in the communication. One reason for the attention to discussion and following implications and the lack of attention to such matters as the history of the problem is that "when you want to persuade, you must not begin the chain of argument too far back, or its length will render the argument obscure..." (Aristotle 155). The team does not go back into the history of the problem they are dealing with. This allows more time for concentration on the actual persuasion. The observer team also does not overwhelm the audience by presenting all of the data and the implications of each finding. "One must not put in every single link, or the statement of what is obvious will make it prolix" (Aristotle 155). By not filling in each link in the chain from data to recommendation, the communicators allow the audience to follow the reasonings and fill in many of the connections for themselves. Effective technical communication presents information to an active, involved audience.

Conclusion

We face an "information revolution" which may reestablish a general interest in the theories of ancient rhetoric (Whitburn 226). After so much time dealing with simple data retrieval, "many men and women are suffering from a failure of nerve. They seem incapable of making any decision without running some kind of empirical research to confirm it" (Whitburn 227). We are discovering, even in a scientific and scholarly world, that technical communication requires more than scientific data; it requires good sense. "If a discourse is to exhibit a man's good sense, it must show that the speaker or writer has an adequate, if not professionally erudite, grasp of the subject he is talking about, that he knows and observes the principles of valid reasoning, that he is capable of viewing a situation in the proper perspective, that he has read widely, and that he has good taste and discriminating judgement" (Corbett 94). Where might one turn if not to the scientific world of specialization? To the common sense world of Aristotle. Technical communication is a combination of scientific data and rhetorical "good sense."

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Appendix A

Independent Test Observer Team Report
to the
Presidential Commission
on the
Space Shuttle Challenger Accident

by

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Eugene G. Haberman
Don E. Kennedy
Michael L. Marx
Wilbur W. Wells

May 27, 1986

I. Summary

The Independent Test Observer team was appointed by the Commission to assist its Accident Analysis Panel in the investigation of the Space Shuttle Mission 51-L accident by determining if the tests and analyses being performed by the Marshall Space Flight Center (MSFC) and Morton Thiokol, Incorporated (MTI) were adequate to provide the information needed by the panel. This included assessing whether the right tests and analyses were being done, whether the resulting information was being properly interpreted, and whether information was sufficient to evaluate all the joint leakage failure mechanisms that were being considered.

We found that, with the exception of analyzing for partial joint rupture from all sources of preexisting cracks, MSFC and MTI have done the appropriate tests and analyses and collected and used the information properly. This has been sufficient to identify several possible mechanisms which acting either singly or in combination can lead to a joint leak.

If it is necessary to obtain more information regarding the leaking mechanisms of the joint, we recommend that full-scale testing be performed. Some members of the team have made specific recommendations regarding additional full-scale testing. We believe further sub-scale tests will not provide additional insight because the scaling factors between sub-scale and full-scale O-rings and joints are not well established.

II. Organization and Responsibilities

A. Charter

The Independent Observer team was formed by the Commission to review and evaluate the Solid Rocket Motor's (SRM) joint and O-ring tests and the analyses being conducted by the MSFC and MTI. Our charter was to answer the following questions:

Are the appropriate tests and analyses being done correctly?

Are the results being interpreted reasonably?

How do the analytical results compare to the appropriate test results?

The answers to these questions were reported to the Accident Analysis Panel of the Commission, led by Major General Donald Kutyna, and are part of this report.

B. Organization

The members of the team and their affiliations are:

Eugene G. Haberman (Chairman)	Air Force Rocket Propulsion Laboratory
Mohan Answani	The Aerospace Corporation
Laddie E. Dufka	The Aerospace Corporation
Don E. Kennedy	TRW
Michael L. Marx	National Transporation Safety Board
Wilbur W. Wells	Air Force Rocket Propulsion Laboratory

C. Approach

The team took a step-by-step approach to observing the tests and analyses being performed. The initial steps were an overview of the activities at MTI and MSFC and a review of how each possible leak mechanism presented by NASA related to the SRM joint and the O-ring was supported by specific tests and analyses. We then looked at each test and analysis to assess its objectives, approaches, and results; the interpretation of these results and the conclusions drawn; the relationship between specific tests and analyses; and the adequacy of the information provided to evaluate the proposed leakage mechanisms. Finally, we summarized our observations, reached conclusions and made recommendations to the Commission's Accident Analysis Panel.

Throughout the process members of the groups made comments on the testing and analyses to the people involved. As a result, several changes were made, such as including grease in the O-ring resiliency tests (since the O-rings in the joint use grease), turning on the instruments during assembly of the referee joint to determine clevis leg deflection caused by placing the shims during assembly, and conducting 70-pound motor tests with undamaged O-rings.

At the midway point, we briefed senior MSFC members of the NASA Task Force Failure Analysis Team. Before preparing our final report, we briefed our observations and concerns to members of the Commission's Accident Analysis Panel and members of the NASA's Task Force. We subsequently held detailed discussions with senior NASA personnel to resolve outstanding issues and to further discuss our observations, concerns, and recommendations.

Tests Evaluation

Tests conducted at both MSFC and MTI in support of the STS 51-L accident investigation fall into the following categories:

A. Basic Material Characterization

The basic material characterization tests included O-ring properties characterization and joint material burning tests. Among these tests, resiliency characterization is by far the most comprehensive test, and the results clearly indicated the slow rebound response of the O-rings at cold temperatures. The test results, therefore, support the O-ring actuation time delayed by the low temperature failure mechanism. The O-rings were also tested for the presence of defects and inclusions, and the results indicated that their influence on the resiliency was minor. The joint material burning test was strictly qualitative and indicated the potential sources of black smoke. An additional observation was that white or gray smoke could turn black in the presence of oxygen.

Several ares of uncertainty relative to O-ring quality became apparent during this review. Splicing is carried out by a proprietary process, which precludes positive control to assure that changes that may require requalification are not introduced without approval by a customer. There is no requirement in the controlling documents that precludes splicing in a permanent twist that could distort the O-ring in its groove, nor is there an inspection procedure at MTI to detect a built-in twist.

Inspection of O-rings for inclusions has revealed high density metallic slivers and particles of iron oxide, silica, and calcium salts. Acceptance specification STW-7-2875 prohibits acceptance of hard white inclusions over 0.010-inch diameter, all visible black inclusions, and metallic inclusions of any size.

In one instance, traceability of one group of O-rings to the parent material's source and lot was completely lost by the supplier. Parts or materials of unknown pedigree therefore apparently were accepted for critical application.

B. Cold Flow to Characterize Joint Performance

In an attempt to characterize joint performance, several tests were carried out. Among these, the most significant tests were the O-Ring Blow-by Dynamic Test, the Discrete Increment Piston Cone Test and the Ice in Joint Test. The O-Ring Blow-by Dynamic Test simulated the full scale joint rotation, pressurization rate, and O-ring cross section (0.280-inch diameter) but was sub-scale with respect to the diameter of the joint. The results provided information about the influence of cold temperature, of initial squeeze, and of gap opening on the sealing capability of the joint and effectively used resiliency data to predict the leakage. They showed that low temperature and high squeeze consistently resulted in leakage, thus supporting the O-ring seal failure mechanisms relating to low-temperature and high-squeeze effects. The Ice in Joint Test qualitatively demonstrated that the secondary O ring could be pushed off its seat, thereby preventing it from sealing properly.

Putty installation into the small diameter full cross section joint used in the MTI Dynamic Vacuum Putty Extrusion Test appeared to be nonrepresentative of the full-scale joint. Applying putty layers into a small diameter restriced area, as compared to a large diameter (virtually straight) annulus, could create different putty functional characteristics. However, the results indicated that joint assembly could create black blowholes in the putty and that cold putty (30^{o}) without blowholes could significantly delay pressurization of the primary O-ring cavity.

The other tests in this category, such as Putty Blow Through, provided qualitative indications further substantiating that putty could hold pressure off the primary O-ring. The colder the temperature, the longer the blow through was delayed, possibly holding pressure off the primary O-ring long enough for joint rotation to occur. The O-ring Leak Port Integrity Test showed that leakage from this port was highly unlikely.

C. Full-Scale Joint Simulation

MTI has completed two phases of the three-phase test series designed to characterize the behavior of the clevis joint. The objective of the tests was to provide reliable displacement data for a typical lightweight joint under a constant internal pressure. The gap opening was compared with an analytical model, and the comparison was reasonable. It is our observation that this setup can be used to conduct several more tests to fully characterize the clevis joint and further validate the model.

The "Short Stack" full-diameter abbreviated segment apparatus was used to determine the influence of ice in the joint and its effect on the spreading of the clevis. The deflections measured were very small, which indicated that ice would not appreciably distort the joint.

D. Hot-Firing Environmental Simulations

The 5-inch-diameter hot-firing motor tests were conducted to get preliminary data for O-ring response to various defects and to develop design data for the 70-pound (propellant) hot-firing motor. Hence, while the motor operated at high-pressure and high-temperature conditions it was configured with only one O-ring and did not represent the true motor geometry. Qualitative data indicated that an O-ring joint can sustain leakage without an immediate burn through.

The 70-pound motor was a test bed that used the full-size clevis joint cross section and a motor diameter of 10 inches with durations of up to 70 seconds. It did not allow for dynamic joint rotation, and, therefore, tested only the static joint condition. The results indicated that a leaking joint could be plugged by aluminum oxide and other deposits in induced leak paths. There was considerable randomness in these results when burn through mechanism simulation was attempted. The results, however, showed that a slow leak in the joint or that an initial leak could be plugged by combustion products.

E. Assembly Damage

The full-diameter "Short Stack" was used to conduct tests for possible O-ring damage produced during joint assembly. During these tests, the segments were purposely misaligned axially while being assembled. Results showed that even during extreme conditions, no appreciable damage to the O-rings was found. However, because of the short height of the segments, the configuration was considered too flexible to provide meaningful results. The degree of misalignment was also believed to be extreme relative to realistic stacking conditions.

A similar test conducted by MSFC on a small sector of the full-scale joint showed that slivers of metal could result from improper assembly of the segments when they are excessively out of round or when assembly techniques produce too much interference causing a flat-on-flat condition. Both the small sector and "Short Stack" assembly tests also showed that considerable O-ring stretching can occur during an out-of-axial alignment assembly. Overall, these tests indicated that improper or careless assembly could produce damage or contamination contributing to initial seal leaking in the joint.

IV. Analyses Evaluation

The following analyses were performed in support of the STS 51-L investigation:

A. Structural Analyses of SRM Segments, Field Joints and Seals

The loading environment for structural analyses was determined from telemetered data, flight event reconstruction, analyses, and measured natural environments. A number of finite element models ranging from 2-D axisymmetric to 3-D nonlinear were prepared to evaluate the dynamic effects of bending and shell modes on field joint response, the effects of elastic propellent, the interaction of joint and pins, and the O-ring response. The results of analyses performed by MSFC and MTI match very well with the "Referee Test" data. However, the comparison was made only for one case of constant internal pressure.

The O-ring response analysis, based on the assumption that the O-ring is made of alinear elastic material, has provided qualitative data regarding the sealing mechanism. The analyses indicate that too much compression in the O-ring is harmful. In that event, when the O-ring occupies almost the entire gland volume and touches gland walls, it may not actuate properly to provide an effective seal. The assumptions made in the model make the results valuable for qualitative purposes only. These results tend to support the contributing mechanism of maximum O-ring squeeze limiting pressure assisted actuation of the seal coupled with the O-ring's capability to follow the sealing surface.

The fracture mechanics analyses conducted by MSFC, with respect to joint rupture due to mating loads and membrane rupture resulting from in-flight stresses showed that case rupture due to assembly and in-flight membrane rupture were unlikely. There is, however, a need to carefully examine the stresses in the clevis joint due to residual stress and induced loading, including mating, to adequately determine whether the joint could partially rupture from an undetected preexistent crack.

B. Flow and Thermal Analyses

Flow and thermal analyses were performed by MSFC in an attempt to explain the transition of the puff of smoke observed at 0.668 seconds into a hot jet at 58 seconds. The three scenarios considered were (1) the initial leak at liftoff continues throughout the 0 to 58-second period, limited by the deposit of aluminum and other debris; (2) the initial leak at liftoff continues throughout the 0 to 58-second period, limited by alumina and/or insulation and putty deposits, and at 58 seconds the blockage breaks open due to vibrations or closing of the joint resulting in burn through; and (3) the initial leak at liftoff does not continue past 5 to 6 seconds, and the leakage is sealed by alumina and/or insulation and putty debris, and at 58 seconds excessive vibrations or joint continues throughout the 0 to 58-second period, limited by alumina and/or insulation and putty deposits, and at 58 seconds the blockage breaks open due to vibrations or closing of the joint resulting in burn through; and (3) the initial leak at liftoff does not continue past 5 to 6 seconds, and the leakage is sealed by alumina and/or insulation and putty debris, and at 58 seconds excessive vibrations or joint motions break the alumina deposit and cause rapid burn through. The analyses thus far have not been able to favor one scenario over the other.

Additional flow and thermal analysis was conducted to determine the effect of inhibitor flaws and whether a debond between the propellent and the insulation could result in case of joint burn through at the appropriate time. Inhibitor flaws and debonds on both the upper and lower segments were analyzed, and the results indicated that burn through was not likely at the time and place it is believed to have occurred.

V. Conclusions

The review of Tests and Analyses conducted at MSFC and MTI led us to the following conclusions:

1. Inadequate quality control procedures for determining O-ring quality was indicated.
2. Insufficient analysis was performed for partial joint rupture emanating from all sources of prexistent cracks.

3. Adequate analyses and tests have been conducted to indicate that SRM inhibitor flaws, propellant debonds adjacent to the joint, leak check port leaks, and case membranes rupture from a preexisting craack are unlikely sources for burn through in the SRM.
4. Tests and analyses performed indicated that putty holding pressure, thereby delaying O-ring pressurization; low temperature adversely affecting O-ring resiliency; ice unseating the secondary O-ring; case diameter mismatch, resulting in near metal-to-metal contact, producing excessive squeeze that delays or prevent pressure-assisted actuation of the O-ring; and assembly damage could contribute to seal leakage.
5. Testing and analysis were performed which only approximate the operation of the full-scale joint and possible leaking mechanisms. Therefore, some caution is needed in projecting the operation of small-scale tests to full-scale hardware. In fact, it is apparent the operation of the full-scale joint and its leaking mechanisms is not fully understood.
6. Tests appear to support that a slow leak or a leak which becomes plugged by combustion products and soot can occur. Analysis indicates that a delay burn through is possible as a result of a slow leak or a leak that stops and later resumes.
7. Tests and analyses need further correlation.
8. In general, the results of the tests and analyses performed

were interpreted properly, and the data was used correctly.

VI. Recommendations

1. If it is necessary to obtain more information regarding the leakage mechanisms of the SRM joint, we recommend that full-scale, full-diameter testing of the SRM joint be performed.

2. A more in-depth analysis for partial joint rupture emanating from all sources of preexistant cracking in the joint should be done.

3. Better O-ring quality control is needed, especially in the areas of avoiding twist in splicing, inspecting for inclusions, and pedigree.

4. Correlation of analyses and test results should continue.

VII. Additional Comments

Several members of the team (Haberman, Kennedy, and Wells) have strong recommendations for what should be included in additional tests. The remaining members of the team (Dufka, and Marx) believe that specific test recommendations are not warranted and should not be included in this report.

From Haberman, Kennedy, and Wells:

Additional full-scale, full-diameter tests are recommended to provide increased understanding of how the SRM joint operates if it is necessary to further define joint operation and its leakage mechanisms.

The joint's operating environment should be simulated as accurately as possible during the testing and should include consideration of external loads (due to "twang," External Tank attach struts, aerodynamic forces, ets.); internal loads (due to motor pressure, pressurization rate, thrust, etc.); temperature; water or ice in the joint; variations in hardware dimensions (i.e., O-ring dimensions, seal gap, segment ovality, inhibitor gap, repaired sealing surfaces, etc.); and putty variations (as affected by aging under representative temperature and humidity conditions, joint rotation, inhibitor gap, leak check pressurization, etc). Many of these variables could be evaluated adequately in cold-gas pressurization tests with the MTI Short Stack and Referee Test hardware. The Short Stack could be used for assembly and O-ring leak-check tests to determine when and where back blowholes occur. It could also be used to evaluate the initial response of putty and O-rings before joint rotation water/ice in the joint, dimensional/fit variations, external loads, as well as temperature and putty conditions.

Critical points of interest in these tests are how the primary O-ring seal moves and seals as the joint rotates open under the influence of internal motor pressure and how O-ring performance is affected by the above variables. An important question, not answerable in the sub-scale tests is "Will the full-scale O-ring move and seal if part of it starts to do so?" This is important because the compression of the O-ring (which is a critical factor in O-ring sealing, especially at low temperatures) is not uniform around the full-scale joint.

We also recommend that further full-scale tests be done to characterize SRM joint performance under hot-firing conditions to assess the viability of the slow leak and the leak/stop-leak/leak scenarios as explanations for the STS 51-L joint failure. The joint environmental simulation hardware could be used for these tests; however, a minimum duration of 5 seconds should be considered. Specific test variables should be selected based on the results of the already completed sub-scale tests and full-scale tests recommended above.

THE APPLICABILITY OF ARISTOTLE'S RHETORIC IN TECHNICAL COMMUNICATION

by

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B.A., Winthrop College, 1985

AN ABSTRACT OF A REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF ARTS

Composition and Literature

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1987

ABSTRACT

During the seventeenth century, the tie between art and science was broken and, as a result, ancient rhetoric found no place in the presentation of scientific information. Until recently, this division between science and art still existed. Now we are beginning to see ancient theories of rhetoric as important tools in technical communication. Even as some in technical communication acknowledge that theories of ancient rhetoric appear in their discourse many, in both science and the humanities, have retained the division.

This paper examines the division that actually exists between technical communication and ancient rhetoric as presented in Aristotle's Rhetoric. Aristotle believed that discourse involved more than a simple presentation of data. Communication also involved the use of deliberation, artistic proofs, various appeals, and a certain amount of style in presentation.

We are beginning to realize that much of what is included in Aristotle's Rhetoric also appears in effective technical communication. Technical communication presents data in order to establish inferences which lead to recommendations. Technical communication is communication. Therefore, many of Aristotle's theories on communication are applicable.