"Fire Protection in the 90's Without Halon 1211 and Halon 1301"

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When I was asked by Dr. Robert Tapscott to deliver the keynote address for the HALON ALTERNATIVES TECHNICAL WORKING CONFERENCE here at the New Mexico Engineering Research Institute, I was somewhat at a loss for a topic. This was in the fall of 1990 after my return from participation in HALONS AND THE ENVIRONMENT '90[1] conference which was an international meeting jointly sponsored by the Swiss Fire Protection Association and the National Fire Protection Association. During the course of this meeting I listened to many papers projecting many different points of view. However, the one viewpoint that seemed common to me was a decreasing reliance on the clean agents Halon 1301 and Halon 1211 that we have come to know so well over the past 20 years.

I would, therefore, like to take some of your time this morning and reminisce just a little bit and tell you what it was like, what happened and what its going to be like in the *1990's* with the certain removal of Halon 1301 and 1211 as clean agents available to us as fire protection specialists. In order to facilitate this I would like to take you back to *1970* when I first joined Ansul and was introduced to the art and science of fire protection. At that time it was probably more art than science. During the early *1970's* the halons were just being introduced to the fire protection community. There was at that time no defined market and there were no so called essential uses for these products.

Du Pont had begun to introduce Halon 1301 as an effective alternative to some of the conventional extinguishing agents in a few selected market areas. Perhaps an indication of the lack of specific markets for this product is indicative of the fact that several major market development campaigns were conducted in the early *1970's.* One gets a feeling for the scope of this by reviewing a Bibliography of the Halon Literature dated May *1978* which was prepared by Miller and Kenney at Factory Mutual Research[2]. As of *1978* there

were over 770 literature citations relating to all aspects of halon fire protection. I seriously doubt if there have been that many literature citations in the entire history of sprinkler fire protection. This is not intended to indicate that we have not advanced the state-of-the-art in the application of water through sprinkler systems. It merely points out the tremendous complexities associated with the clean agents - Halon **1301** and Halon **1211** in understanding how they worked, where they worked, and why they worked.

As I indicated, in the early 1970's there were no defined markets for clean agent fire protection. It therefore became incumbent upon the chemical agent manufacturers, the fire equipment manufacturers, and in some cases the fire equipment distributors to participate in programs to demonstrate the efficacy of Halon **1301** and Halon 1211 in certain applications. As ah indication of this interest the first standard covering halogenated fire extinguishing agent systems was published by the National Fire Protection Association in 1970[3]. These early documents laid down the initial performance requirements for Halon **1301** total flooding and local application systems as well as the same requirements for Halon 1211. It was not to become evident until some ***4-5*** years later that because of concerns over the toxicity associated with Halon **1211**, its use in a total flooding application in normally occupied spaces would be precluded by requirements in **NFPA 12B.** For this reason a natural division developed in the application of these two halons which was never really picked up in the **NFPA** standards because to this day, a standard exists for Ealon **1211** engineered systems for which the applications are very few, at least in the United States. This is not to say that other countries in the international community may not use these documents.

With the initial performance requirements laid down for Halon 1301 total flooding systems, Du Pont and members of the Fire Equipment Manufacturers Association embarked collectively and individually on market development programs. Perhaps the most significant of which that I was involved in was a program that occurred during 1970 through 1972. This program was referred to as the Du Pont Industry Halon 1301 Joint Computer Fire Test Program[4]. It involved work conducted separately between Du Pont and three of the manufacturers of fixed fire suppression systems. The three manufacturers were Cardox (soon to be Chemtron), Fenwal and Ansul. Each manufacturer working with Du Pont undertook separate phases of an overall study designed to demonstrate the effacacy of Halon 1301 total flooding systems in electronic data processing/computer facilities. The results of this progran which took nearly two years to complete formed the basis to the introduction of Halon 1301 as a primary means of fire protection for computer facilities. Not all parties agreed with the results of this test program and the debate continued sometimes heatedly for a number of years over the effacacy and the need for clean agent fire protection for these facilities as opposed to the use of water sprinklers whose primary function at that time was the protection of the facility. Much has been said regarding this particular issue and it was only with the advent of hardening of computer equipment that water became a viable alternative to Halon 1301.

During this same period of time the United States Coast Guard undertook a project entitled An Investigation of the Effectiveness of Halon 1301 as an Extinguishing Agent for Shipboard Machinery Spaces[5]. This program conducted under the auspices of the United States Coast Guard Safety Equipment Branch was to be picked up on shortly by the United States Navy who conducted a similar program at the U.S. Naval Damage Control facility in Philadelphia, PA[6]. There were several conclusions that are noteworthy with regard to the

Coast Guard program. Halon **1301** was deemed to be at least as effective as carbon dioxide on large scale machinery space fires. A minimum **10** second discharge was established to prevent excessive decomposition **of** the Halon **1301**. The concentration of the decomposition products was determined to be less hazardous than the concentration of the fuel products of combustion. Adequate mixing could be achieved with relatively small number of well positioned nozzles. The Navy extended this a step further in their program by demonstrating the effacacy of Halon **1301** on multi-dimensional fires including pressure fires impacting on bilge space fuel -in-depth type fires during their test program. Both **of** these programs significantly assisted in the development of both a military and commercial marine fire protection market for Halon **1301** that is recognized today around the world.

The interest in halogenated fire extinguishing agents became **so** great in the early **1970's** that the National Academy of Sciences conducted a symposium entitled An Appraisal Halogenated Fire Extinguishing Agents". Among the topics covered included a session on toxicology, a session on applications, and a session on engineering. This was truly an international effort with participants from Europe as well as the United States taking part in presenting and listening to the papers that were offered as part of this symposium. Considerable controversy still existed relative to the life safety aspects of both Halon **1301** and Halon **1211**. As I've indicated previously significant efforts on the part of the agent manufacturers, the fire equipment manufacturers, and in some cases fire equipment distributors and government agencies resulted in extensive test programs designed to demonstrate the efacacy and applicability of Halon **1301** and Halon **1211** to certain areas.

Halon **1211** was a development of ICI Ltd. in the U.K. and was not manufactured in the United States until after significant market development activity had

been undertaken by ICI both alone in in conjunction with fire equipment manufacturers. It was determined early on that for reasons previously stated regarding overall health effects that the principal market in the United States at least for Halon 1211 would be that associated with portable and wheeled fire extinguishers. Significant testing was undertaken by various manufacturers in conjunction with ICI to demonstrate the Class A, Class B and Class C capabilities of Halon 1211 and also significant efforts were undertaken with the U.S. Air Force to demonstrate the applicability of Halon 1211 as an alternative to dry chemical for ramp fire protection purposes. It should be noted here that halogenated hydrocarbons had been known and used for many years in engine in-flight fire suppression systems principally. It was therefore a logical extension to demonstrate the effacacy of Halon 1211 for other applications involving aircraft fire protection. Several programs emanating from AFESC Engineering and Services Laboratory, Air Force Engineering and Services Center, Tindall Air Force Base,' were funded to demonstrate Halon 1211 as a viable alternative to dry chemical for the Air Force needs regarding both ramp fire protection as well as crash fire rescue vehicle fire protection twinned with either aqueous foam forming foam (AFFF) or dry chemical.

Much of the preliminary testing with the exception of the machinery space programs conducted by the Navy and the United States Coast Guard were conducted on small scale simulation of what was expected to be full scale hazards. As such the nagging question of scaling of extinguishment concentrations continued to persist. In late 1972 a program was undertaken between Du Pont and Ansul entitled The Halon 1301 Threshold Extinguishment Program[9]. This particular program was conducted to determine whether or not certain small scale tests would scale to a large scale enclosure which consisted of a volume of approximately 10,000 cu. ft. Several diverse fuels were selected and

tested both under ambient fuel temperature conditions as well as elevated fuel temperatures which were five degrees below the flash point of the liquid in question. It was determined as a result of this program that a small scale laboratory technique proposed by Du Pont did not scale adequately. This led to work on an international scale to come up with acceptable methods for determining both threshold extinguishing and threshold inerting concentrations.

ICI took a leading position in advocating the use of the so called "Cup Burner Technique" for determining threshold extinguishment concentrations as well as the use of a spherical steel bomb for determining inerting concentrations. Once again another joint industry program was undertaken involving ICI, Du Pont, Fenwal, Factory Mutual Research and Ansul. The result of this was the validation of laboratory scale techniques for determining the appropriate threshold extinguishment concentrations and inerting value that presently exist in both NFPA 12A and NFPA 12B.

One final example will serve to illustrate the extent to which markets needed to be developed for the halon extinguishing agents. The Air Force in 1977 funded a program with Ansul entitled The USAF Flight Simulator Fire Control System Halon 1301 Partial Flooding Technique". This was a program whose specific intention was to determine whether or not a volume could be partially flooded to something between 30 and 50% of the total volume. The concern that the Air Force had was because of the location of its simulators in large hanger-like facilities in which the simulator occupied only the lower space along with its associated electronics and hydraulics. It was the expense to which the Air Force would have to go to flood the entire volume that was of concern. The results of this program showed conclusively that with proper

system design and nozzle placement, in fact Halon 1301 could be used to partially flood a volume such as occupied by a flight simulator. There were many other programs conducted involving what is now the U.S. Department of Energy, other private and public agencies all of which were for the stated purpose of validating or invalidating halogenated extinguishing agents for particular applications or for particular reasons. The interested reader is referred to the Factory Mutual Bibliography for more specific information.

It is now time to talk about what has happened. Ever since the first indications by Roland and Minlena that chlorofluoro carbons could contribute significantly to ozone depletion has the debate raged within the scientific and environmental communities as to the validity of the data upon which this contention was based. It is not our intention to review in detail the history of that debate. Suffice it to say that the use of chlorofluoro carbons as aerosol propellants and the acknowledgement by major manufacturers such as Du Pont in 1976[12] that it may be necessary to restrict the production of R11 and R12 with the beginnings of what we have now come to know as the CPC and halon/ozone problem. The announcement in 1985 in an article published in Nature by J.C. Farmin et al[13] announcing large losses of total ozone in the Antarctica set off a controversy which is only now beginning to settle. In the initial stages of the debate concerning the effect of halons on stratospheric ozone depletion arguments raged back and forth between environmentalists concerned with the ozone depleting potential of these materials and people in the fire protection community concerned with the denial of use through production restrictions and eventual phaseouts of clean agent fire protection market that they had worked so hard to develop and for which the agents in certain cases were so ideally suited.

The argument was heated at times but the evidence is increasingly obvious that the consequence of ozone depletion is something that the international community is not willing to live with. This is evidenced by the fact that in 1989 the Montreal Protocol[14] was enacted. This treaty which has now been signed by 52 countries presently calls for both production restrictions and gradual phaseout of both CFC's and halons. The current treaty calls for a freeze at the 1986 production level in 1992 followed by a reduction to 50% of the 1986 production level in 1995, and a complete phaseout by the year 2000. Many have argued that these are far too severe restrictions to place on the halons which account for only 2-3% of the total pounds of CFC produced in the U.S. It should be noted however that the ozone depletion potential has been estimated at from 2.8 to 13 times greater than that assigned to R11 for Halon 1211 and Halon 1301 respectively. The recent findings regarding the decrease in stratospheric ozone in the United States to almost twice what was estimated continue to add pressure to our concerns regarding the efficacy of both Halon 1301 and Halon 1211 in the fire protection engineering markets in the United States for the very near future. It is extremely likely that the international community will take the lead along with the U.S. Environmental Protection Agency imposing further restrictions and earlier phaseouts on CFC's and halons. Mr. William Riley, administrator of the U.S. EPA was recently quoted in Chemical Week Magazine[15] as using this new data to call for earlier phaseouts of the production of CFC's and halons in the United States. It should also be noted here that in an earlier issue of the same magazine Du Pont has announced joint toll production for certain CFC's and halons with both Great Lakes Chemical and Allied Signal in the United States. ICI had earlier withdrawn its production of Halon 1211 from the United States and moved it back to the United Kingdom. In addition the European community is reacting in that Atochem announced that it would shut down its French production facilities for certain CFC's and halons in early 1992. It would appear

that the manufacturers do not see a bright future for the on-going production of **CFC's** and halons.

One other aspect impacts in the United States and that comes from **two** different pieces of federal legislation. The first is a 1989 Omnibus Budget Reconciliation Act which places increasingly progressive taxes on **CFC's** and halons to the point where in 1994 the production of Halon 1211 and Halon 1301 will not be an economic feasibility. The second piece of legislation is the Clean Air Act of 1990 which established a production phaseout that somewhat accelerates the provisions of the Montreal Protocol in that it requires a 10-15% reduction in the 1986 production level per year starting immediately. It also classifies group one substances as any substance having an ODP greater than 0.20. The impact of these acts will be to make the production of virgin Halon 1301 and Halon 1211 in the United States economically unfeasible very shortly.

Thus **we** are faced in the 1990's with the possibility with having to provide fire protection engineering without any real clean agent capability that affords life safety simultaneously with being effective. There is no question that Halon 1301 and Halon 1211 as virgin produced materials will not be a factor in the commercial and military market in the foreseeable future. There are other sources of Halon 1211 and 1301 that can be drawn upon to provide some relief during that period of time, while alternative clean agent materials are being developed.

This of course gets into the issue of recycling and reclamation. This is an issue which has only been recently addressed and only partially addressed in the publication of a standard by Underwriters Laboratories UL Standard 2006[16] covering Halon 1211 Reclamation and Recycling Equipment. This document

lays down specifications for the performance and the operation of the equipment needed to effectively recover and recycle Halon 1211. It does not however provide for any assay to determine whether or not that material meets any particular composition specification such as the U.S. Military Specifications[17] and the ISO 7201[18] Standard. You will notice that little or no work is available in the open literature regarding the recycling and reclamation of Halon 1301 and certainly no one has begun to address the mixtures of Halon 1211 and Halon 1301. It is my understanding through private correspondence[19] that a research contract is in progress involving McDonald Douglas, Kidde Aerospace, and Du Pont under the auspices of the FAA regarding the subject of reclamation and recycling of Halon 1301. Extensive studies have been conducted by Taylor and Wagner and reported in the International Symposium (ref. 1) as well as a draft of the UNEP Technical Options Committee Report[20] regarding the estimated availability and stocks of both Halon 1211 and Halon 1301. This study is an attempt to quantify the available supply of halon produced in 1986 based on variable equipment life between 10-20 years and also between 25–75% recovery and also as a function of decreasing production levels up to 30% below the 1986 level. One of the final conclusions in this document is the statement "it would not appear that provision of any future allowance for continued production of Halon 1211 or Halon 1301 to fulfill future essential needs is even necessary or desirable". I caution you that this is a draft of the UNEP Technical Options Panel and as such the previous conclusions quoted are not finalized.

It does bring up however the issue of so called essential use. This is a term which has been much used in recent years to try and define those uses where no other existing extinguishing agent i.e. carbon dioxide, water, foam, or dry chemical can be used in place of halon. It usually invokes a life safety consideration in conjunction with effectiveness. An example is the concern

expressed by the oil producing community on the North Slope of Alaska who use Halon 1301 as an inerting gas in their flammable and combustible liquid process areas and on certain pump stations on the Alyeska Pipe Line. The flammable and combustible liquid process areas and certain pipe line stations obviously are manned and therefore life safety become of paramount importance. The concern of the oil producing community is that the discontinuation of production of Halon 1301 will leave them without what they consider to be necessary fire protection for their facilities. If the information regarding quantities of Halon 1211 and Halon 1301 available for recycle and reclamation are even somewhat accurate there is certainly enough of a supply available through that process to provide protection to the North Slope facilities. However, under the provisions of the Clean Air Act which was previously cited, an exemption has been granted for production of Halon 1301 and Halon 1211 through the year 2005 for selected areas, one of which is the North Slope oil producing community.

I prefer to take a different approach and suggest to you that the purpose of this meeting is because there are **no** essential uses for halon. There is no way to offset the potential damage associated with depletion of stratospheric ozone that allows any justification whatsoever for the continued production of these materials. It is therefore the purpose of the working conference to focus on what needs to be done to bring about the development of clean agents which are environmentally acceptable. Just as in 1970 there was no market for the then clean agents Halon 1211 and Halon 1301 I believe we have to take the same position today and say that there are no markets in which the continued use of Halon 1211 and Halon 1301 is justifiable using virgin produced materials. Adequate interim fire protection can be provided through the use of alternative extinguishing agents such as water, carbon dioxide, foam and dry chemical, as well as the reclamation and recycling of Halon 1301 and Halon

1211 to ensure their continued supply for reuse in those areas deemed critical from a life safety point of view such as the North Slope oil community. I believe it is incumbent upon the people involved in research and development to further advance the work that has progressed so nicely to date and continue the development of those chemicals for which there will be a market.

It may be a market that will require development just as the halon market required development in the 1970's, however, there was always and there will always be a need for clean agent fire protection where the agent provides life safety as well as effectiveness. A number of the major chemical manufacturers have announced candidate replacements for both Halon 1301 and Halon 1211. These materials have been evaluated and will continue to be evaluated with increasing scrutiny placed on their environmental consequences as well as their life safety and fire extinguishing effectiveness characteristics. I will not attempt to predict the outcome of research efforts for you. I simply do not know. I do know however that traditionally what we set our mind to we have been able to accomplish, not always without compromise, but we have been able to accomplish it.

Extensive work is being conducted presently in both the public and the private sectors. The U.S. Air Force has funded projects here at New Mexico Engineering Research Institute as well as with the National Institute of Standards and Technology very heavily in looking at replacements for halon extinguishing agents. The U.S. Navy has embarked on a program. I've already briefly mentioned the FAA Halon 1301 Recycling Program and also there is a project being co-funded by the U.S. EPA and a consortium of oil producers from the North Slope involving the evaluation of alternatives to Halon 1301 for purposes of inerting. These are but a few of the projects and do not at all include the extensive research and development that has been devoted on the

part of the chemical agent manufacturers - Du Font, ICI, Great Lakes, Atochem in search of replacement agents. There are many other projects that are on-going.

It is my hope and my belief that we will continue to push forward collectively setting aside our differences to resolve the issues before us and develop effective safe clean agents for use by the fire protection community. The market I am sure exists for this agent just as it did in 1970 for the halons. We are now faced with the challenge of developing materials that are required to satisfy the needs of that market. I certainly wish you well in the dialogues that will take place in the next two days here in Albuquerque at this first Halon Alternatives Technical Working Conference.

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