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# **Glovebox Windows, Fire Protection and Voices From the Past**

By Bernie Till

## **Introduction**

“Study the past – what is past is prologue.” These words appear as the motto on a pair of statues at the National Archives Building in Washington DC. They are also the opening sentence in the preface of a document written in August of 1956 entitled “A Summary of Accidents and Incidents Involving Radiation in Atomic Energy Activities – June 1945 thru December 1955.”<sup>1</sup> This document, one of several written by D.F. Hayes of the Safety and Fire Protection Branch, Division of Organization and Personnel, U.S. Atomic Energy Commission in Washington DC, and many others are often forgotten even though they contain valuable glovebox fire protection lessons for us today.

## **The Role of the American Glovebox Society**

The American Glovebox Society Standard of Practice (SoP) for Glovebox Fire Protection is, at the time of this writing, nearing its first publication. After several years of work by the Standards Development Committee, the document stands as perhaps the best source of information ever available on the narrow subject of gloveboxes and fire protection. While it is clear that the document, once employed, will improve the level of fire protection for gloveboxes regardless of the application – nuclear, pharmaceutical, biomedical, or any other, the likely greatest benefit of the document is that it is the culmination of years of research which can be preserved for future designers and users of gloveboxes.

In development of the standard of practice, numerous studies, papers, and incidents from decades ago were identified. The standard of practice preserves this information two ways – by direct reference and in appendices. In some cases, the documents identified, located, reviewed and referenced were not previously known or publicly available. Is this information important? That is for history to decide but one recent example perhaps illustrates why we are destined to repeat history if we don't learn from it.

The American Glovebox Society was invited to have a representative witness a fire test of a glovebox in August 2007. This was the first known fire test of an assembled glovebox (other tests were performed on glovebox components) since the early 1970's. The glovebox was tested to confirm the adequacy of the guidance provided in current glovebox fire protection design criteria – in particular, prescribed methods for reducing fuel contribution by combustible glovebox components. . Many people were surprised by the test results. The polymethylmethacrolate window ignited and contributed a substantial amount of fuel resulting in higher than anticipated temperatures. The test was aborted less than halfway through the planned 2 hour duration. Most fire protection engineers would anticipate such results given the fact that the plastic materials generally have a higher heat of combustion than other fuels – typically following the hydrocarbon fuel curve versus the standard time-temperature curve (ASTM E-119) routinely used to evaluate components, materials and systems.

### **The Importance of the Past**

Should this have been anticipated by glovebox designers or users? Only if we remember our history or previous glovebox research. In typical fashion, research often follows some event. This is probably true for the evolution of fire research regarding gloveboxes. For example, the very first fire described in Appendix E of the Standard of Practice for Glovebox Fire Protection involved the burning of a plastic glovebox window. Appendix E contains all known fire events involving gloveboxes and hoods and the first event listed occurred on March 16, 1956. The fire which occurred at Rocky Flats the next year on September 11<sup>th</sup>, 1957, however, is even more indicative of the issues associated with plastic glovebox windows. This fire event remained the most costly glovebox fire until eclipsed by the Mother's Day fire, May 11, 1969 also at Rocky Flats which is one of the most costly industrial fires in US history.

Recognition of the potential fire hazard with gloveboxes is first described in a report by the United Kingdom Atomic Energy Authority in 1959 entitled "Some Aspects of Fires in Glove Boxes."<sup>2</sup> Referenced in the document are two U.S. Atomic Energy Commission Serious Accident Bulletins, number 129<sup>3</sup> (explosion in August 1957) and 130<sup>4</sup> (1957 Rocky Flats fire). These tests involved fires inside gloveboxes.

The first discussion on the subject of glovebox construction including window materials appears to have been published in June 1961. "A Review of Glove Box Construction and Experimentation"<sup>5</sup> by C. J. Barton, Oak Ridge National Lab (ORNL-3070), in the abstract, references "a series of fires and explosions...during the last five years..." This report concludes that safety glass "is the presently preferred window material in the U.S.

for applications having any possible fire hazard....” At least 22 fire and explosion incidents occurred between March 1956 and the time Barton published his report.

One of the most comprehensive documents on the subject was published June 20, 1962,<sup>6</sup> “as a result of various studies into the fire and safety conditions prevailing in AEC glove box facilities” by the ad hoc committee developed to “formulate criteria and guidelines” for gloveboxes. Four subcommittees were created including one each for 1) glovebox construction materials and components, 2) glovebox operations, 3) safety and fire protection and 4) Health Physics. Glovebox windows are discussed in multiple sessions and first conclusion in the safety and fire protection section is the recommended use of “non-combustible materials.”

A report by H.V. Rhude of Argonne National Laboratory in July 1962, “Fire and Explosion Tests of Plutonium Gloveboxes”<sup>7</sup> describes a series of glovebox fire tests with ethyl alcohol, magnesium chips and a combination of the two. Also reported were results from explosion testing. This report concluded that “safety glass has good fire resistance” and appears to be the first to note that “it would add very little fuel to the fire.”

Several studies were performed for the Atomic Energy Commission by Factory Mutual Research Corporation in the late 1960’s with one published in 1967 and three published in 1969. Two are of particular interest, “Glovebox Fire Safety”<sup>8</sup> and “Glovebox Window Materials”<sup>9</sup> published in 1967 and 1969 respectively. The other two address explosion overpressure<sup>10</sup> and improved fire resistant glove materials.<sup>11</sup> Both of the former discuss

glovebox window materials and concur in their recommendation for noncombustible window materials such as wired glass and laminated safety glass as the preferred options.

Domning and Woodard published “Glovebox Fire Tests”<sup>12</sup> November 6, 1970 with the objective of reporting results of fire tests of “shielded gloveboxes to determine the necessary action to minimize damage which might result from a fire within a glovebox.” Of particular interest in this document is the recognition that other window materials “are more suitable than methacrylate” and that “after a glove becomes involved in a fire, sufficient heat is generated to burn a methacrylate plastic window.” This report was also among the first to conclude that “little difference in the burning characteristics was noted” between self extinguishing and fire retardant varieties. The conclusion reached was that “pyrex glass and fire-rated wire glass were found to be the best noncombustible window materials and are recommended whenever they can be used.”

### **The Present**

The testing of the glovebox in 2007 seems at least in part to have revalidated some of what we’ve known about the fire protection concerns of combustible windows. Followup small scale testing of other combustible shielding material should have results available in the future. Other testing of alternative materials in 2003 provided additional data points regarding the combustibility of some newer polycarbonate window materials. Renewed interest in glovebox fire protection – in part precipitated by the efforts of the American Glovebox Society to publish a new standard on the subject, have opened new doors for research. Small scale testing of window materials currently proposed for use at some

facilities has already been performed. Further evaluation of such subjects as glovebox fire suppression options, combustible waste characterization and others are planned with funding from the U.S. Department of Energy in the interest of validating current design guidance, developing alternative designs or to reduce uncertainty in safety analyses.

### **The Future**

Confucius (551 BC – 479 BC) said “study the past if you would define the future.” The past of glovebox fire protection includes the fire events which have occurred and previous research – some of which has been discussed here. Numerous other historical documents on the subject of glovebox fire protection are available and will be referenced in the forthcoming Standard of Practice for Glovebox Fire Protection – AGS-G010-2009. Topics include much more than just window material selection. Many of these documents were not publicly available before the effort to develop the SoP. Some of these studies will be discussed in future articles. The preservation of this research can and should shape codes and standards by providing a technical basis for the requirements. Future standards activities will likely identify even more as research continues. All of these sources, in conjunction with newly proposed research and the AGS document itself represent the future of glovebox fire protection.

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#### References:

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<sup>2</sup> Jackson, C., Hodge, T.W., Swingler, D.H., Smith, A.J., “Some Aspects of Fires in Glove Boxes,” United Kingdom Atomic Energy Authority Research Group, Engineering Division, Atomic Energy Research Establishment, Harwell Berkshire, 1959.

<sup>3</sup> United States Atomic Energy Commission, Serious Accident Bulletin No. 129, “Explosion in Glovebox Fire at Plutonium Facility,” October 28, 1957. This Bulletin has not been located. The source for this is “Glovebox Fire Safety” cited below.

<sup>4</sup> United States Atomic Energy Commission, Serious Accident Bulletin No. 130, “Small Metallic Plutonium Fire Leads to Major Property Damage Loss,” November 27, 1957. This Bulletin has not been located. The source for this is “Glovebox Fire Safety” cited below.

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<sup>7</sup> Rhude, H.V., “Fire and Explosion Tests of plutonium Gloveboxes,” Argonne National Laboratory, Argonne Illinois. July 1962

<sup>8</sup> Factory Mutual Research Corporation, “Glovebox Fire Safety – A Guide for Safe Practices in Design, Protection and Operation”, TID-24236. 1967

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<sup>10</sup>Yao, C., deRis, J., Bajpai, S.N., Buckley, J.L., “Evaluation of Protection from Explosion Overpressure in AEC Gloveboxes,” Factory Mutual Research Corporation. FMRC Serial No. 16215.1 December 1969

<sup>11</sup> Factory Mutual Research Corporation, “Evaluation of Improved Fire Resistant Glove Materials for Gloveboxes - A Glovebox Fire Safety Application ,” TID-25086. 1969

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