SUPPLEMENTAL INFORMATION CONCERNING THE METHODOLOGY USED BY IIT RESEARCH INSTITUTE TO PREDICT THE EFFECTS OF POOL FIRES ON HAZARDOUS MATERIAL TANK CARS

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Washington, D. C. 20590
January 20, 1983

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INTRODUCTION

IIT Research Institute (IITRI) developed a computer program to calculate pressures, liquid levels, and tank wall temperatures in pressure tank cars subjected to fires. The inputs for the program are thermodynamic properties of the lading, the pressure setting of the tank car, the safety relief valve capacity, the thermal system conductance, and the fire conditions.

IITRI reported some of their initial computer calculations in a paper entitled, "Thermal Protection/Safety Valve Relationships for Tank Cars in Pool Fires," M. R. Johnson, June 4, 1981. IITRI has also used their computer program for subsequent calculation.

The purpose of this report is to provide supplemental information on the IITRI methodology. This report is based on conversations among the authors and Dr. M. R. Johnson, the principal investigator at IITRI. Dr. Johnson is preparing an addendum to his original paper which will contain the information contained in this report.

DESCRIPTION OF METHODOLOGY

IITRI developed the following relationship between the thermal system conductance and the maximum plate temperature achieved in the pool fire simulation tests of § 179.105-4:

overall system conductance BTU/hr $ft^{2o}F$	maximum plate temperature of 100 minute pool fire simulation test
100-200	1,100
12.0	890
5.4	800
4.0	750
3.0	700
2.3	650
1.65	575
1.5	560
1.4	540

IITRI calibrated its computer program by comparing the results with the two full scale fire tests of LPG cars subjected to fires. They used thermodynamic property data developed by the University of Maryland. IITRI obtained agreement between the experimental and calculated results if they used an external fire temperature of 1500^oF and an initial heat flux of 25,500 BTU/hr ft^2 over the entire tank car surface. They used these fire conditions in all of their subsequent calculations of upright specification 105 tank cars.

IITRI's calculations showed that a thermal protection system for which the maximum plate temperature never exceeds 800°F in a pool fire simulation test per § 179.105-4 and a safety valve sized according to § 179.105-7 would enable the tank car to be empty of liquid at failure and to never exceed the pressures allowed in § 179.100-5 and § 179.102-11 (i.e. 82½-90% of tank test pressure). IITRI's calculation also showed that a thermal protection system for which the maximum plate temperature never exceeds 540°F in a pool fire simulation test per § 179.105-4 and a safety valve sized according to Appendix A of the AAR Specifications for Insulated Tank Cars would also enable the tank car to be empty of liquid at failure and to not exceed the tank car test pressure. It should be noted that with the latter thermal protection system-safety valve combination, the pressure may slightly exceed the maximum pressures allowed in § 179.100-15 and § 179.102-11. The FRA Office of Research and Development does not consider this to be a serious safety hazard.

CONCLUSIONS

The FRA Office of Research and Development believes that it is important that at failure the tank car is empty of liquid. As was discussed in the NPRM for Docket HM-144 (41 FR 52324), "previous experimental tests and computations have shown that the severity of a failure is directly related to the amount of liquid lading present at time of failure." This belief is confirmed by the full scale pool fire tests sponsored by FRA at the White Sands Missile Range (references 1, 2, and 3) and by analysis (references 4, 5, and 6). The testing and analysis indicate that the severity of a tank car failure is heavily dependent on the mass released. The Office of Research and Development also believes that it is very speculative to assume that tank cars can survive pressures in excess of their tested tank pressure. These pressure tests are conducted under ambient temperatures and with no mechanical damage. In accident situations the tank car may be subjected to high temperatures, uneven heating, and mechanical damage. The IITRI methodology can be a useful guide to estimate the thermal protection needed to ensure that tank cars subjected to fires be empty of liquid at failure and never exceed the tank car test pressure.

REFERENCES

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