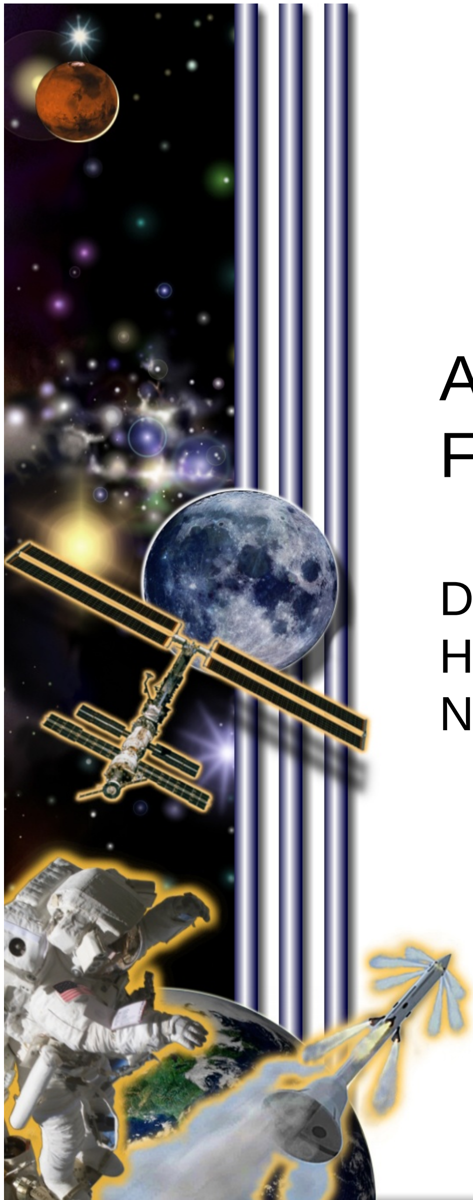

Applicability of ISO 16697 Data to Spacecraft Fire Fighting Strategies

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Agenda

- Selected variables affecting oxygen consumption during spacecraft fires
- General overview of ISO 16697
- Estimated amounts of material consumed during combustion in typical ISS enclosures
- Discussion on potential applications

Selected Variables Affecting Oxygen Consumption During Spacecraft Fires

- The post-combustion oxygen concentration in spacecraft enclosures depends, among other variables, on the environment’s initial oxygen concentration and pressure, enclosure’s volume, materials’ heat of combustion, combustion and mixing efficiencies, etc. The rate of oxygen depletion depends on the heat release rate, mixing efficiency, etc.

General Overview of ISO 16697

- ISO 16697 provides a method to determine oxygen concentration flammability thresholds of aerospace materials. The flammability threshold approach has been used to establish quantitative correlations between ground flammability test data and flammability behavior under ventilated low and micro-gravity spacecraft conditions. The flammability threshold information could also be used to predict the amount of material consumed during combustion before the oxygen concentration flammability threshold is achieved.

Estimated Amounts of Material Consumed During Combustion in a Typical ISS Rack before the O_2 Concentration Falls Below Values Noted in Column 1

Post-combustion O_2, vol % (starting: 20.9% O_2, 14.7 psia)	**Estimated amount of material consumed (g)**					
	For most common materials (HoC approx 6 kcal/g)		For materials with HoC at the high end (i.e. PE, 11 kcal/g)		For materials with HoC at the low end (approx 3 kcal/g)	
	Likely	Conservatively estimated	Likely	Conservatively estimated	Likely	Conservatively estimated
19	19.8	29.1	10.8	15.9	39.6	58.2
18	30.2	44.4	16.5	24.3	60.5	88.9
17 (most materials extinguish in ground lab tests)	40.7	59.8	22.2	32.6	81.3	119.5
16	51.1	75.1	27.9	41.0	102.2	150.2
15	61.5	90.4	33.6	49.4	123.0	180.8

Estimated Amounts of Material Consumed During Combustion in a 300 cu ft ISS Module before the O_2 Partial Pressure Falls Below Values Noted in Column 1

Post-combustion O_2 partial pressure torr (starting: 20.9% O_2, 14.7 psia)	**Estimated amount of material consumed (g)**					
	For most common materials (HoC approx 6 kcal/g)		For materials with HoC at the high end (i.e. PE, 11 kcal/g)		For materials with HoC at the low end (approx 3 kcal/g)	
	Likely	Conservatively estimated	Likely	Conservatively estimated	Likely	Conservatively estimated
148	82.6	56.2	45.1	30.7	165.2	112.4
135	182.9	124.4	99.8	67.9	365.8	248.8
IDLH, 100	454.4	309.1	247.9	168.6	908.8	618.2

Estimated Amounts of Material Consumed During Combustion in the CEV Avionics Bay (1 cu m) before the O_2 conc. Falls Below Values Noted in Column 1

Post-combustion O_2, vol % (starting: 20.9% O_2, 14.7 psia)	Estimated amount of material consumed (g)					
	For most common materials (HoC approx 6 kcal/g)		For materials with HoC at the high end (i.e. PE, 11 kcal/g)		For materials with HoC at the low end (approx 3 kcal/g)	
	Likely	Conservatively estimated	Likely	Conservatively estimated	Likely	Conservatively estimated
19	13.2	19.4	7.2	10.6	26.4	38.8
18	20.1	29.6	11	16.2	40.3	59.3
17 (most materials extinguish in ground lab tests)	27.1	39.9	14.8	21.7	54.2	79.7
16	34.1	50.1	18.6	27.3	60.1	100.1
15	41	60.3	22.4	32.9	82	120.5

Estimated Amounts of Material Consumed During Combustion in a 15 cu m Module before the O_2 Concentration Falls Below Values Noted in Column 1

Post-combustion O_2, vol% (starting:20.9 % O_2, 14.7 psia)	Estimated amount of material consumed (g)					
	For most common materials (HoC approx 6 kcal/g)		For materials with HoC at the high end (i.e. PE, 11 kcal/g)		For materials with HoC at the low end (approx 3 kcal/g)	
	Likely	Conservatively estimated	Likely	Conservatively estimated	Likely	Conservatively estimated
19	198	291	108	159	396	582
18	302	444	165	243	605	889
17 (most materials extinguish in ground lab tests)	407	599	222	326	813	1195
16	511	752	279	410	1022	1502
15	615	905	336	494	1230	1808

Potential Applications

- The information would allow conservative estimates of oxygen depletion in space system modules and smaller enclosures, which could be compared with flammability threshold data. This could help define the approach to fighting fires in space systems

- Estimation of the approximate amount of material burned which would deplete the oxygen below the hypoxia limit could allow to evaluate when the astronauts should abandon fighting a fire in an ISS module (or switch from respirators to oxygen supplied, which in itself is not a very good idea considering that the oxygen-enriched exhaled by astronauts would intensify the fire). If the module abandoned is sealed, the amount of material which could burn before the oxygen concentration falls below the oxygen concentration flammability threshold could be estimated.

Potential Applications (Continued)

- Oxygen depletion due to combustion in the ISS racks, CEV Avionics Bay and other enclosures could be evaluated to determine the appropriate response in case of an incidental fire. There may be instances where fire extinguishment measures may not be critical if the amount of material consumed is considered small enough before the combustion subsides due to oxygen depletion.
- However, the eventuality of smoldering combustion should also be considered; cotton, cellulosic materials, and foams could be prone to solid phase combustion, which requires less oxygen than flaming combustion.
- The oxygen depletion estimates for various amounts of materials consumed could also provide a relative perspective on the size of a potential spacecraft fire involving polymers when the fans are turned off.