Environmentally-Friendly Fire Suppression System for Cargo using Innovative Green Technology

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31 October 2019

Overview

- Background and scope of project
- Tests and acceptance criteria
- Experimental rig set up
- Results so far

Background and Scope

- EFFICIENT – (Environmentally Friendly Fire Suppression System for Cargo using Innovative
- Green Technology)
- Funded by the European Union Clean Sky 2 research program
- Collaboration of several Academic and Industrial partners

Background and Scope

Scope:

- To develop and mature potential fire suppression technology for eventual application in the cargo-cabin architecture of next generation aircraft
- Identify a suitable agent which will replace Halon 1301 and will be able to qualify the FAA MPS

Background and Scope

Objectives:

- Identify a suitable AGENT, or mixture of AGENTs, capable of providing the fire suppression specified in DOT/FAA/TC-TN12/11 MPS - not harmful to human health or the environment
- Develop the EFFICIENT Fire Knockdown System (EFKS) capable of delivering the AGENT(s) under a range of environmental conditions simulating those an aircraft would undergo
- Construct a suitable DEMONSTRATOR capable of showing that the EFKS will fulfil all requirements in terms of fire suppression performance

Tests and Acceptance Criteria

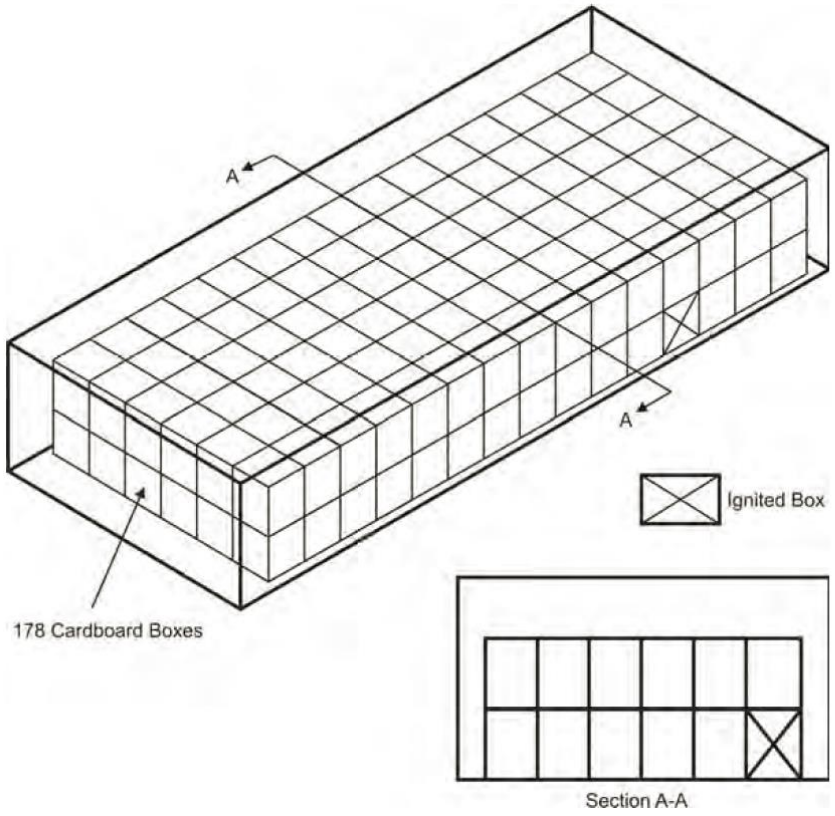
Four test scenarios:

1. Bulk - load fire
2. Containerized load fire
3. Aerosol can explosion (short version)
4. Surface burning fire

Tests and Acceptance Criteria

Bulk – load fire scenario

- 178 cardboard boxes filled with shredded paper
- Each box weighs 1.1kg net
- Ignition triggered through a specially perforated box
- Suppression triggered 1 min after ceiling temperature Reaches 93.3 °C
- Temperatures monitored for 28 minutes

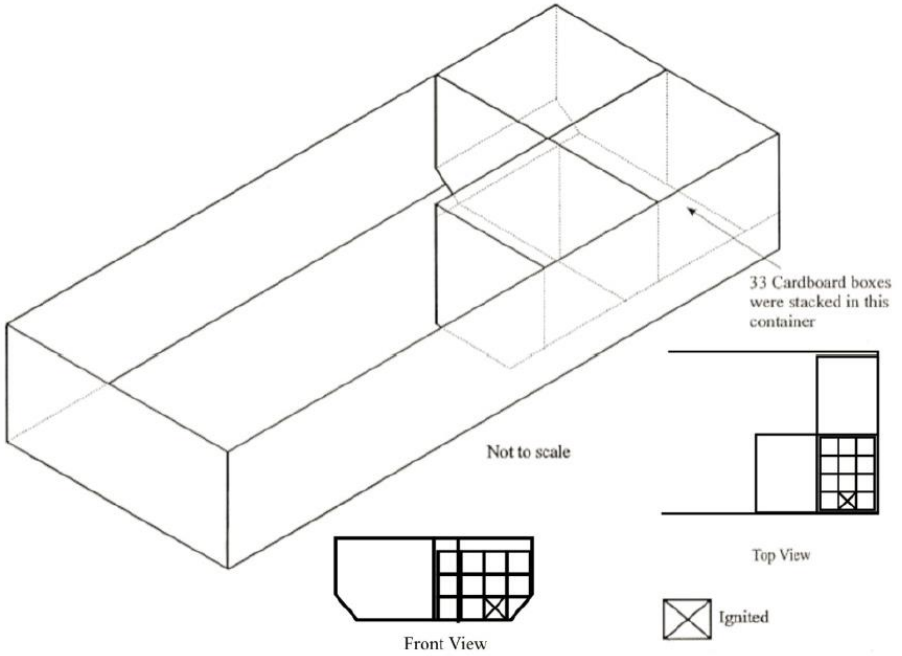


Source: FAA MPS

Tests and Acceptance Criteria

Containerised – load fire scenario

- 3 LD3 containers stacked inside the demonstrator
- One LD3 is filled with 33 boxes
- Ignition triggered through a specially perforated box
- Suppression triggered 1 min after ceiling temperature Reaches 93.3 °C
- Temperatures monitored for 28 minutes

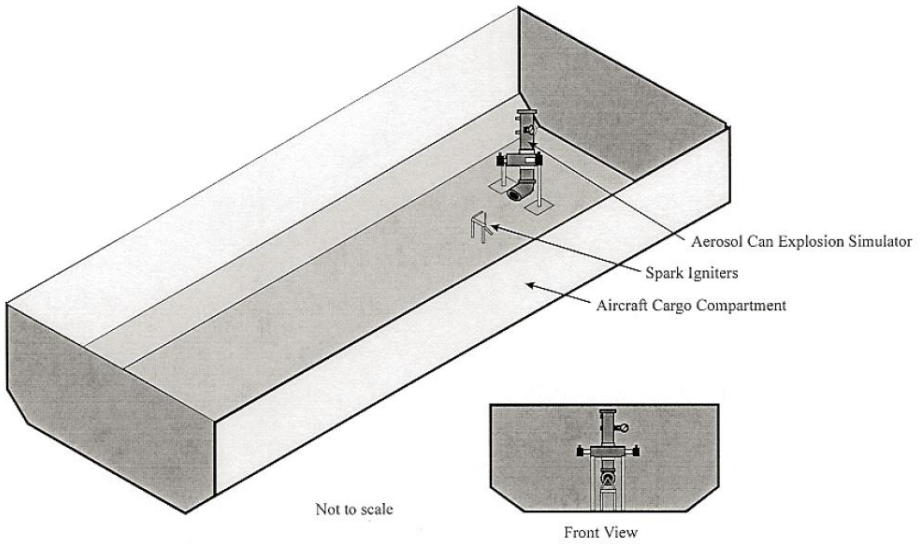


Source: FAA MPS

Tests and Acceptance Criteria

Aerosol can explosion scenario

- Appropriate pressure vessel containing 20% liquid propane, 60% ethanol and 20% water
- Vessel heated to 240psi Internal pressure
- Ignition electrodes 3 feet away are charged with 10,000V
- Mixture released within 0.1sec, 2 minutes after suppression activation



Source: FAA MPS

Tests and Acceptance Criteria

Surface – burning scenario

- Appropriate steel pan containing 0.385l gasoline, 1.9l kerosene and 9.5l water
- Pan located at disadvantaged location
- Ignition electrodes are charged with 10,000V
- Temperatures monitored 2 minutes after suppression activation (60 s after 93.3 °C) for 3 minutes

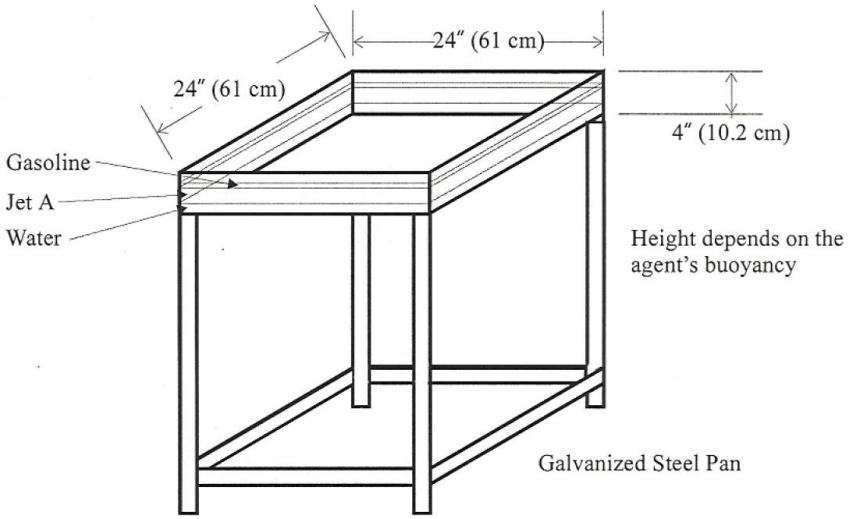


Figure 7. Surface-Burning Fire Pan

Source: FAA MPS

Tests and Acceptance Criteria

Fire Scenario	Maximum Temp. °F (°C)	Maximum Pressure psi (kPa)	Maximum Temp-Time Area °F-min. (°C-min.)	Comments
Bulk Load	710 (377)	Not Applicable	9850 (4974)	Use the data that are between 2 and 30 minutes after suppression system activation.
Containerized Load	650 (343)	Not Applicable	14520 (7569)	Use the data that are between 2 and 30 minutes after suppression system activation.
Surface Fire	560 (293)	Not Applicable	1190 (608)	Use the data that are between 2 and 5 minutes after suppression system activation.
Aerosol Can Explosion Simulation	Not Applicable	0.0	Not Applicable	There shall be no evidence of an explosion. No enhancement of explosion at below inert concentrations.

Synopsis of acceptance criteria - Source: FAA MPS

Experimental Rig Set Up

- Demonstrator manufactured to exact dimensions of wide body aircraft FWD cargo hull (57m^3)
- 33 K type thermocouples installed on ceiling and side walls

- Ports for cargo hull door leakage simulation designed according to MPS – Electric fan extracts air at rate of 23l/s
- Adjustable ventilation system installed

Experimental Rig Set Up

Cargo hull demonstrator

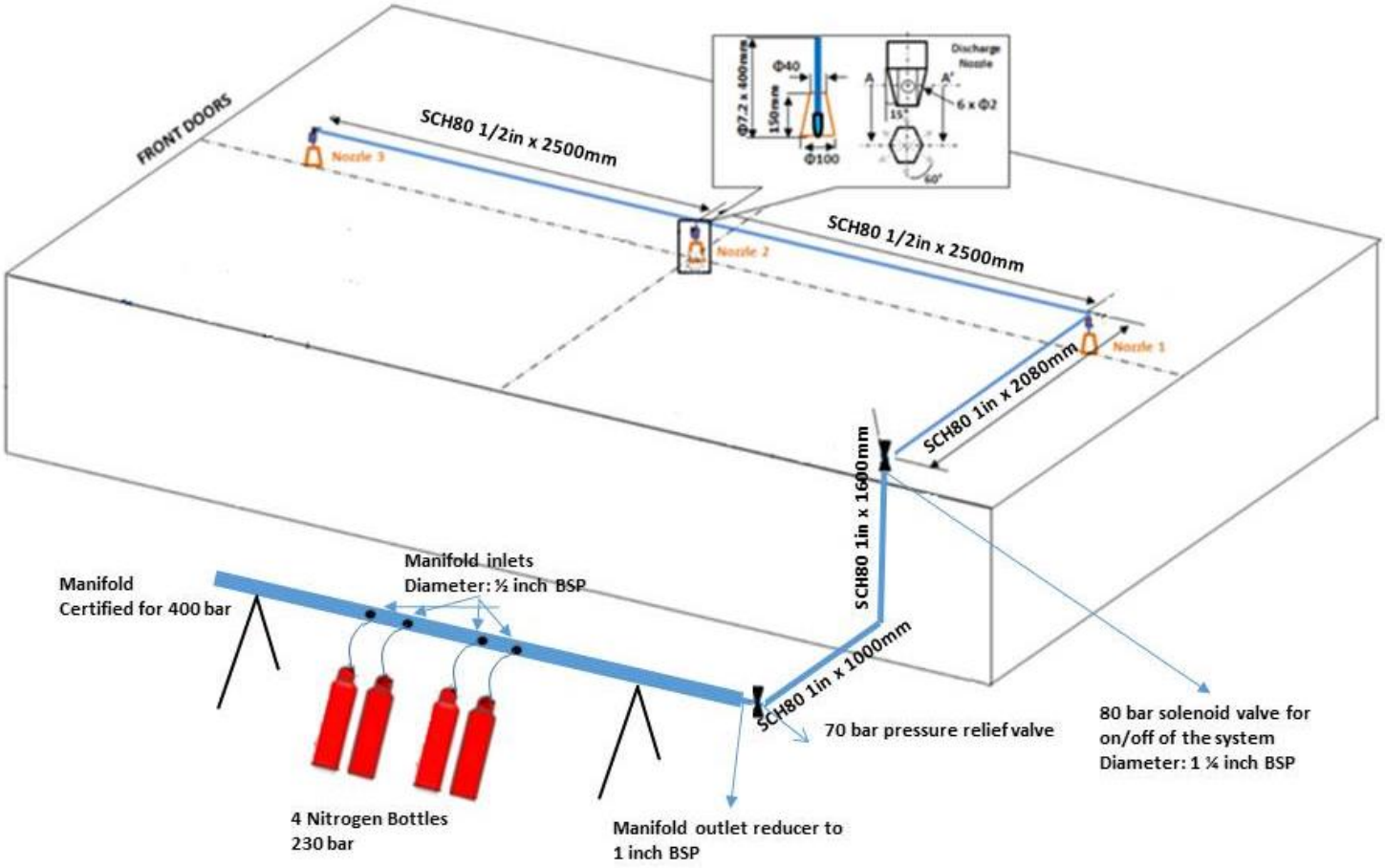
Interior of demonstrator

Experimental Rig Set Up

Leakage simulator

Ventilation and regulation

Experimental Rig Set Up

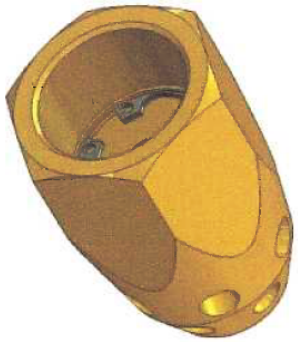


Schematic representation of nitrogen supply for EKFS

Experimental Rig Set Up

Nitrogen distribution for EKFS

Experimental Rig Set Up



ASSEMBLY	ORIFICE	Height	A/F	DN	Design Flow rate	Max Flow rate
Part No	RANGE	mm	mm	mm (inch)	Kg/min	Kg/min
NF35150	1.6-10mm	44	24	15 (½")	23	33
NF35200	7-14mm	55	32	20 (¾")	45	66
NF35250	10-18mm	67	41	25 (1")	90	133
NF35320	12-23mm	82	54	32 (1-¼")	118	175
NF35400	15-26mm	93	63	40 (1-½")	158	235

Nitrogen spray nozzles specification

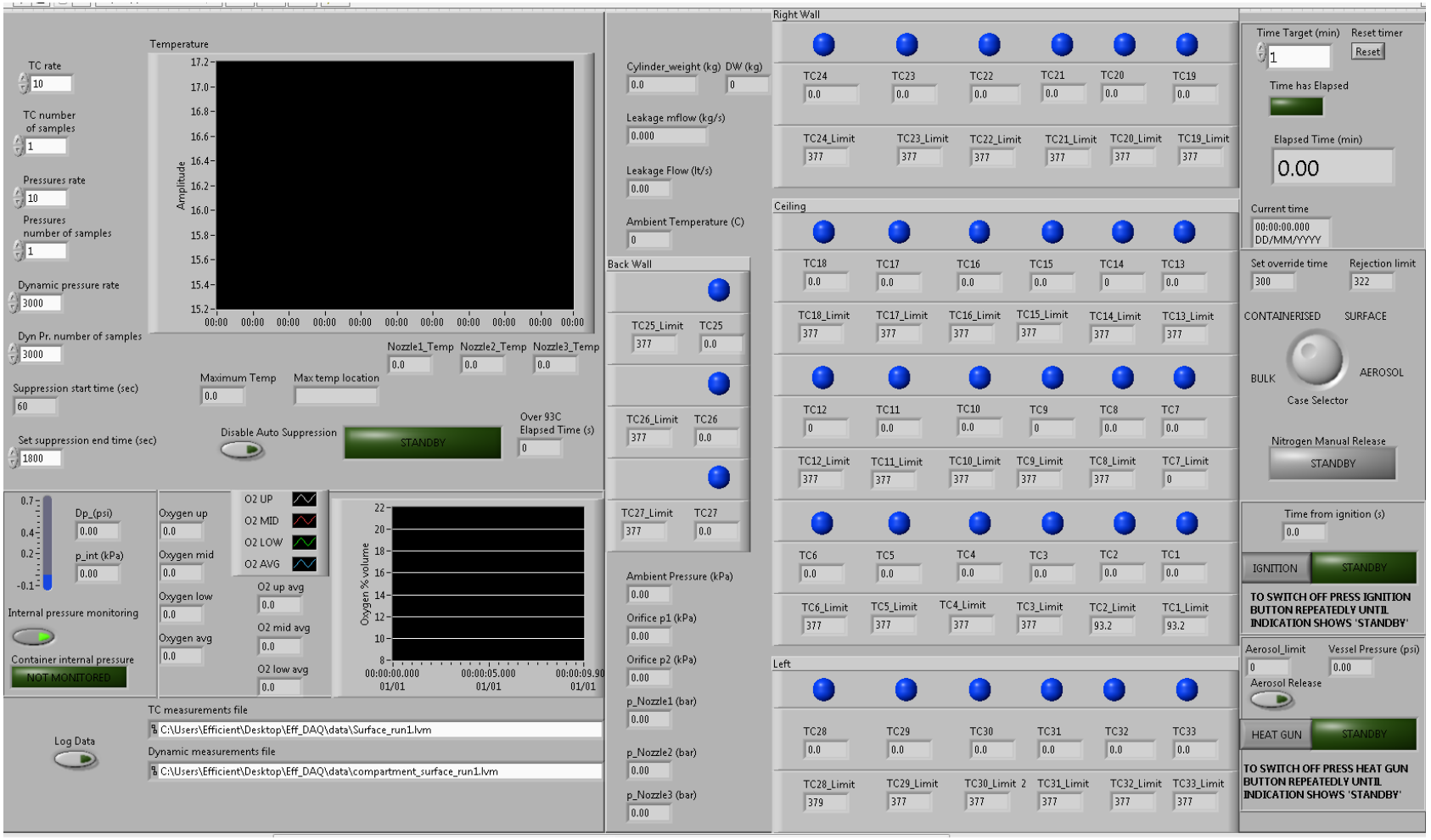
Nitrogen spray nozzle and nitrogen supply arrangement

Experimental Rig Set Up

No	Instrument/ sensor	Type	Measurement	Sensor Type	Range	Accurracy	Sampling	Output	Units	Usage
1	Thermocouples Type K	Thermocouples with standard head and process connection and weather protection	Temperature	K chrome/alumel	1300 C	1C	10 Samples /s	Low Voltage	35	Temperature measurement inside the demonstrator – One for Ambient temperature measurement
2	Pressure Transducer	OMEGA PXM409	Pressure	Differential Pressure	0-5 psid	0.08%	10 Samples/s	10VDC	2	Pressure drop across orifice plate for leakage simulation flow rate measurement
3	Pressure Transducer	OMEGA PXM409	Pressure	Gauge Pressure	0-70bar psig	0.08%	10 Samples/s	10VDC	3	Static pressure of nitrogen before each spray nozzle
4	Pressure Transducer	Kulite XCQ-093	Pressure	Sealed gauge	0-15 psig	0.1%	3000 Samples/s	100mV	1	Overpressure inside the demonstrator
5	Oxygen analyser	XZR-B2-C2	Oxygen Concentration (v/v)	Zirconium oxide	0-25%	0.55%	10 Samples/s	10V DC	3	Agent concentration,
6	One Weight industrial scale	HFC12	mass (kg)	Load cells – digital output	0-1500kg	0.2kg	10 Samples/s	RS232	1	Mass reduction of nitrogen cylinders during suppression

Basic instrumentation

Experimental Rig Set Up



Experiment control interface

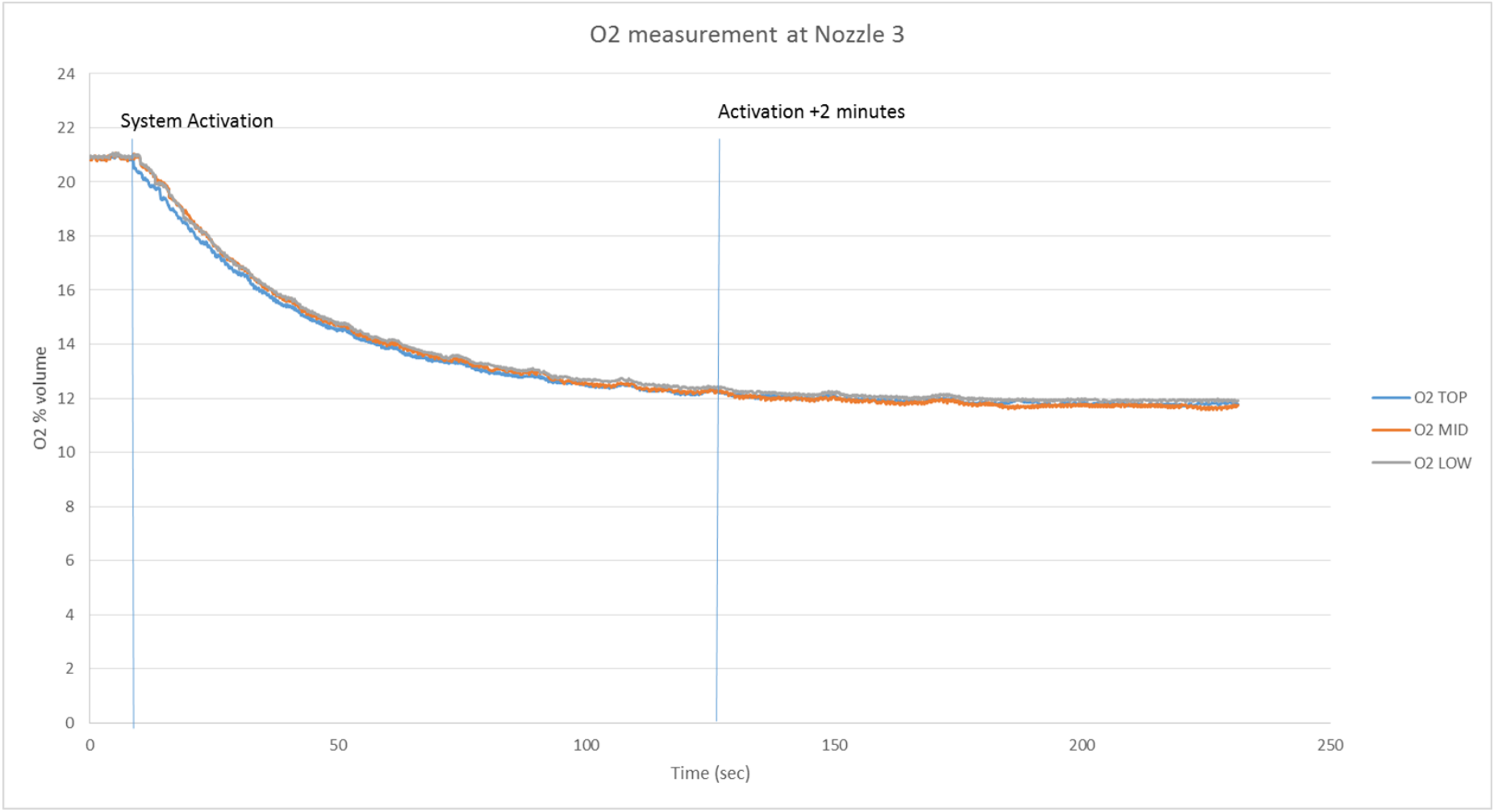
Experimental Rig Set Up

Aerosol can explosion simulation

Results so Far

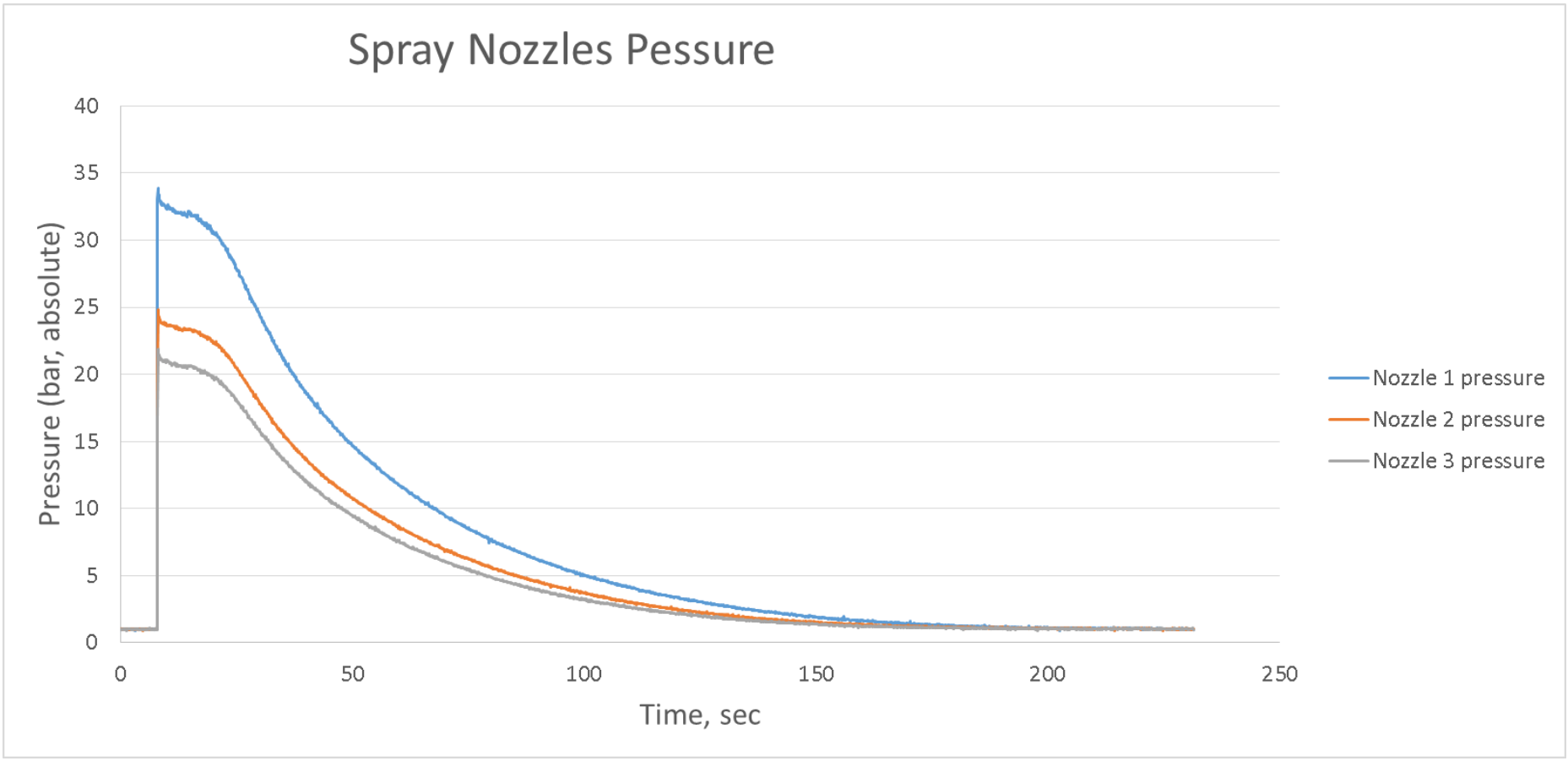
- Baseline nitrogen concentration tests for EKFS
- Nozzles configured at orifice diameters 5mm, 8.5mm and 8.5mm respectively
- Pressure of nitrogen distribution system regulated at 50bar
- Approximately 45kg of nitrogen consumed
- Peak pressure increase inside chamber at 0.4psi
- Oxygen concentration reduced below 12% volume within 2 minutes

Results so Far



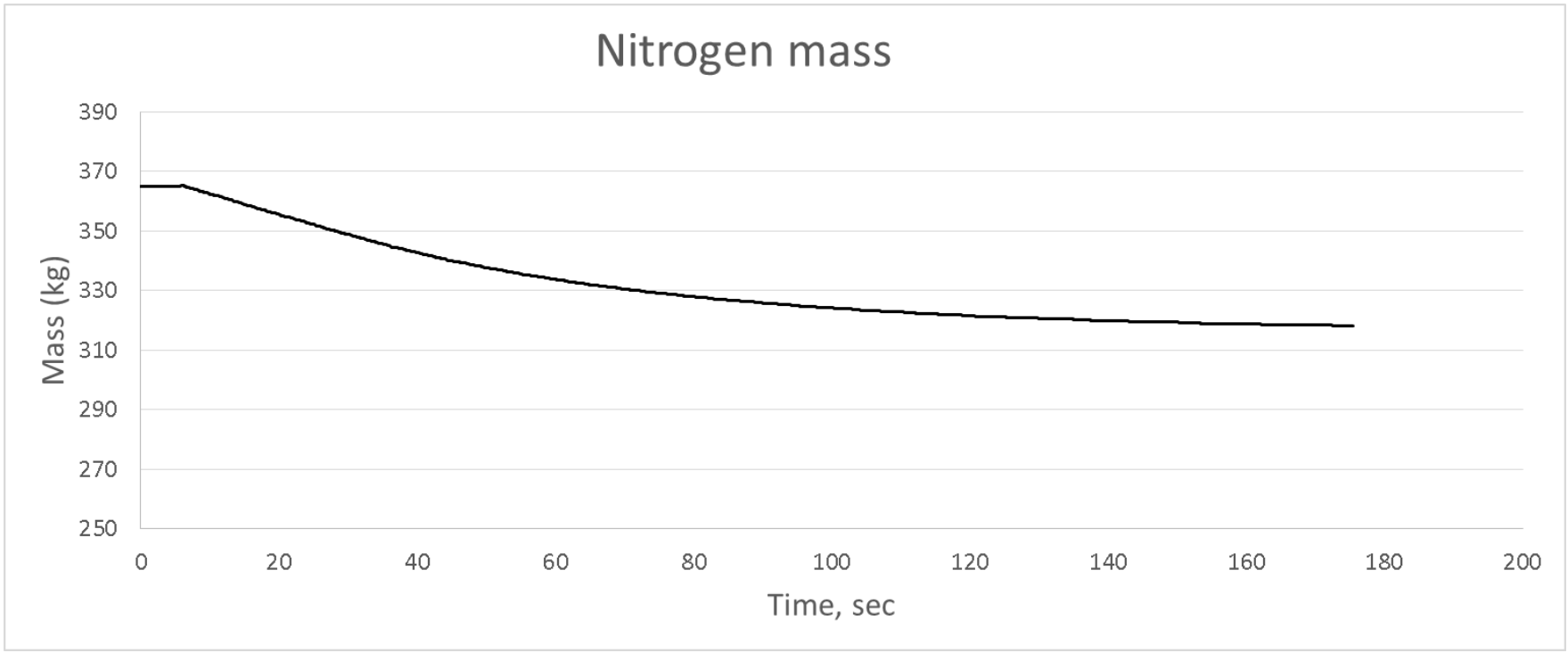
Oxygen concentration reduction

Results so Far



Discharge nozzles pressure

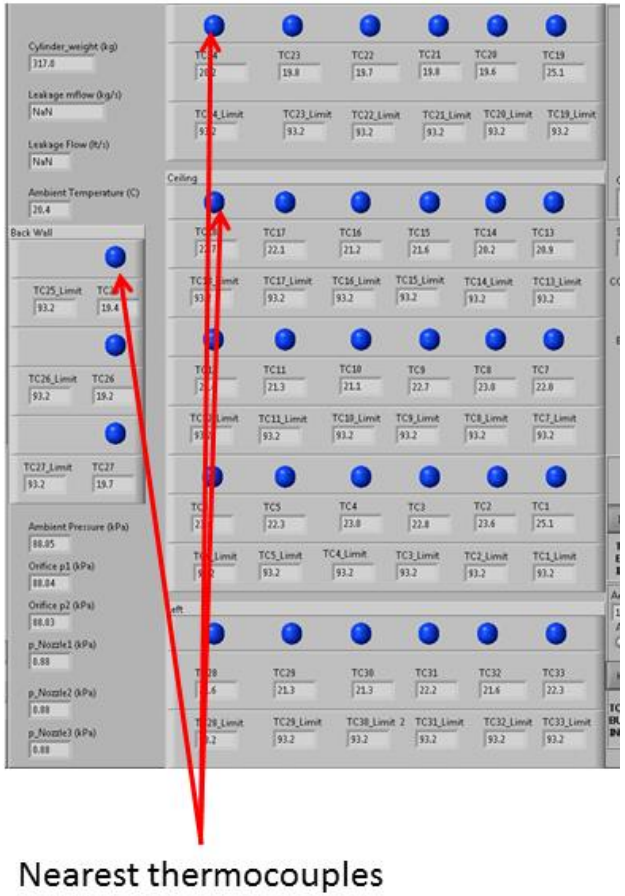
Results so Far



Nitrogen mass consumption during EKFS

Results so Far

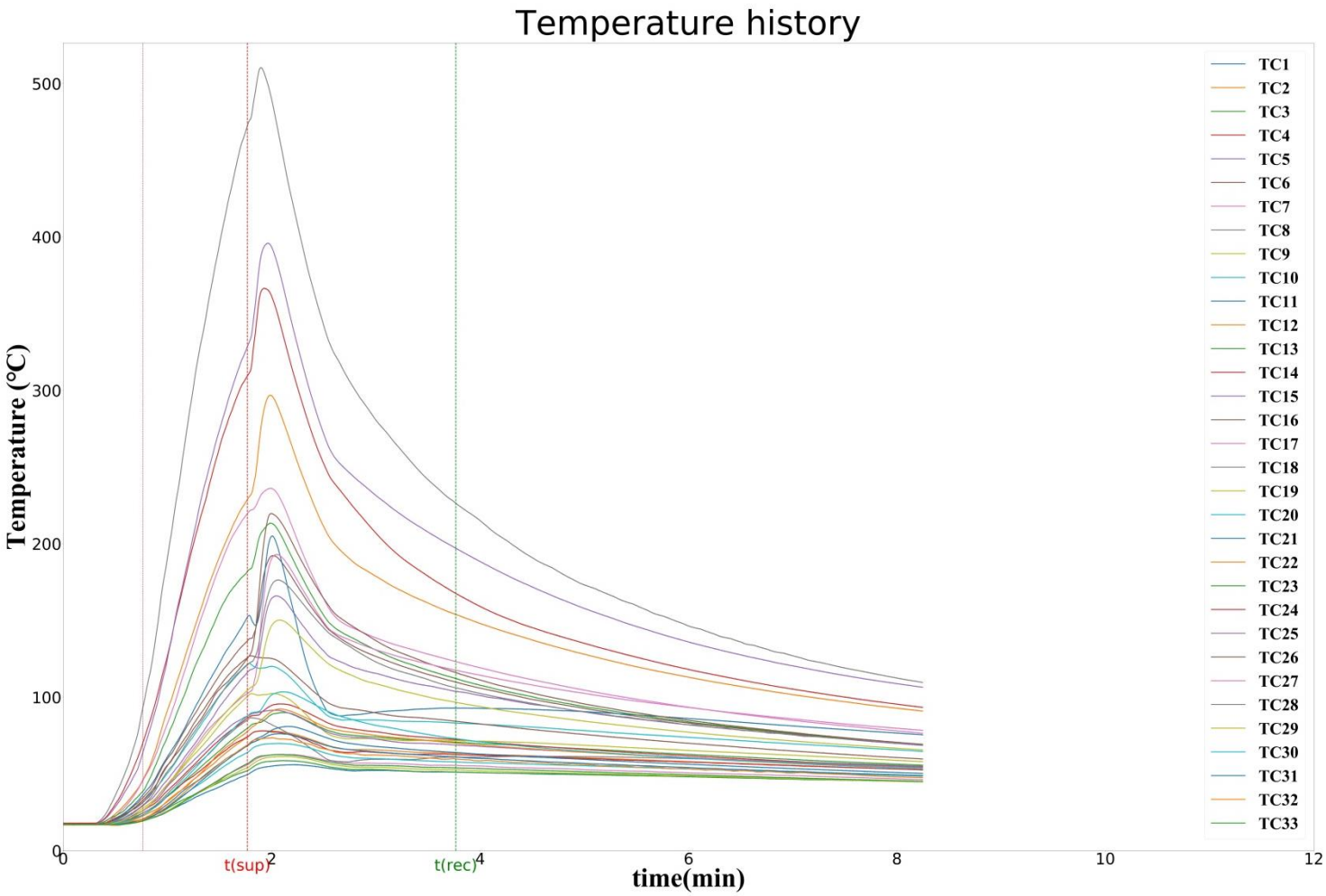
Location of Surface Burning pan



Nearest thermocouples

Surface Burning scenario pan location

Results so Far



Temperature distribution for Surface Burning scenario

Results so Far

- Oxygen concentration reduced to ≈ 10%
- Approximately 34kg Nitrogen discharged

Location	Max temp (°C)	Max temp limit (°C)	Max temp over time (°C)	Max temp over time Limit (°C)	Result
TC18	205.83	293	475.42	608	PASS
TC18	226.55	293	509.46	608	PASS

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