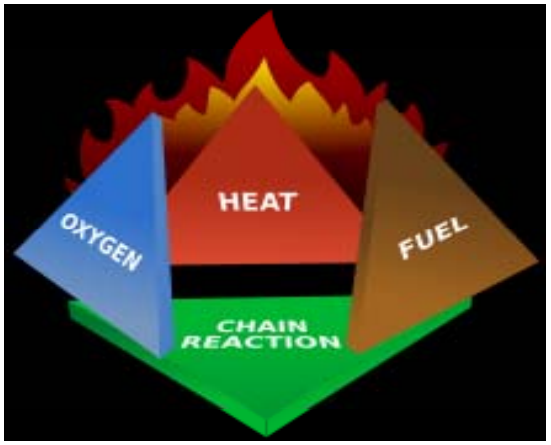
PHYSICS OF FIRE

Fire energy and release rates

Mark Fishlock

FIRE (Combustion)



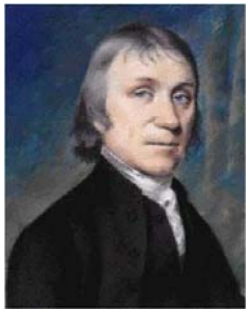
FIRE : a state, process, or instance of combustion in which FUEL or other material is ignited and combined with OXYGEN, giving off light, heat, flame. and various reaction products.

COMBUSTION: any process in which a substance reacts with oxygen to produce a significant rise in temperature and the emission of light

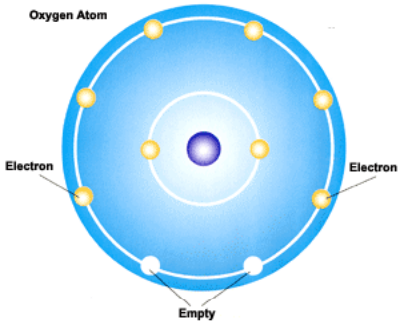
HEAT (energy)

True Combustion is an Exothermic reaction (gives off heat) and is thus self perpetual

The energy given off from a fire is measured in Watts



OXYGEN - O_2



- Abundant in the atmosphere at @ 21%
- Below 18.5% fire activity is greatly suppressed
- Below 16% it ceases.
- Oxygen rich environment is defined as an environment in which the concentration of oxygen is greater than 25% (at STP)
- Combustion has no upper O2 limit (16-100%)

OXYGEN - O_2

Pressure and the atmosphere

Atmospheric pressure = 1.01325 Bar

Partial pressure relates to each component of a gas

For Air this approximates to:

$n = n_{nitrogen} + n_{oxygen}$

=0.213 Bar Oxygen pressure (3psi)

Oxygen rich Fires

Tend to burn at @$2x^2$ rate

(Double the O2 = 16x faster)

Ignition temperatures change

Flammable limits change

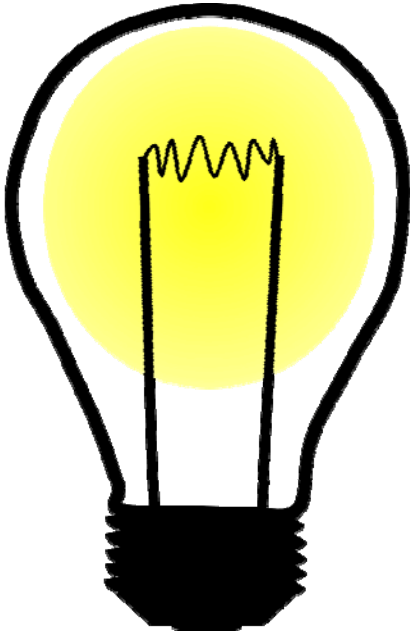
Hard to extinguish

FUEL

- Rated by its potential to release its energy
- It has a **Calorific value** measured in Joules (complete combustion)
- The energy **Release Rate** is speed at which fuel is burnt
- Release rate is normally expressed in normal free air (20.946% Oxygen)

FUEL :Release rate

A Joule is the equivalent of 1 watt for 1 second.



100w Light bulb burning for 10 hours uses:

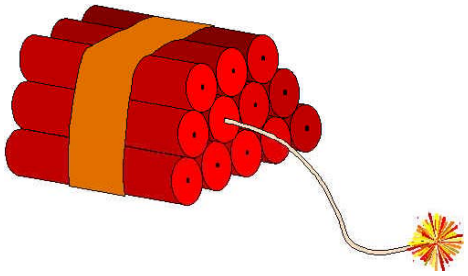
100 x 3600 = 360000J

Or 360KJ (Kilojoules)

Or 0.36MJ (Mega joules)

Or 0.00036GJ (Gigajoules)

FUEL: Release rate



A Tonne of TNT is a unit of energy.
Calorific value equal to
4.184 gigajoules,

A Tonne of Coal (anthracite)
Calorific value equal to
32.5 gigajoules

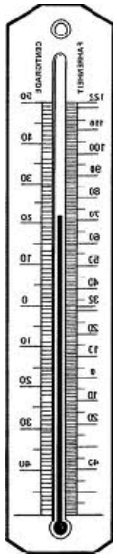
FUEL: Release rate

A Tonne of TNT in a square cube 0.6mx0.6m will burn in 0.00001 of a second

A Tonne of Coal (anthracite) in a cube 1.6m x 1.6m will burn in 8 hours

FUEL: Release rate

Most affected by the fuels ability to use Oxygen:



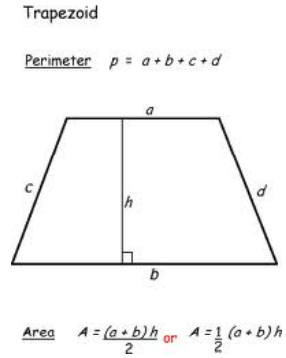
Surface area

Pressure

Temperature

Mix ratios

Flame disruption

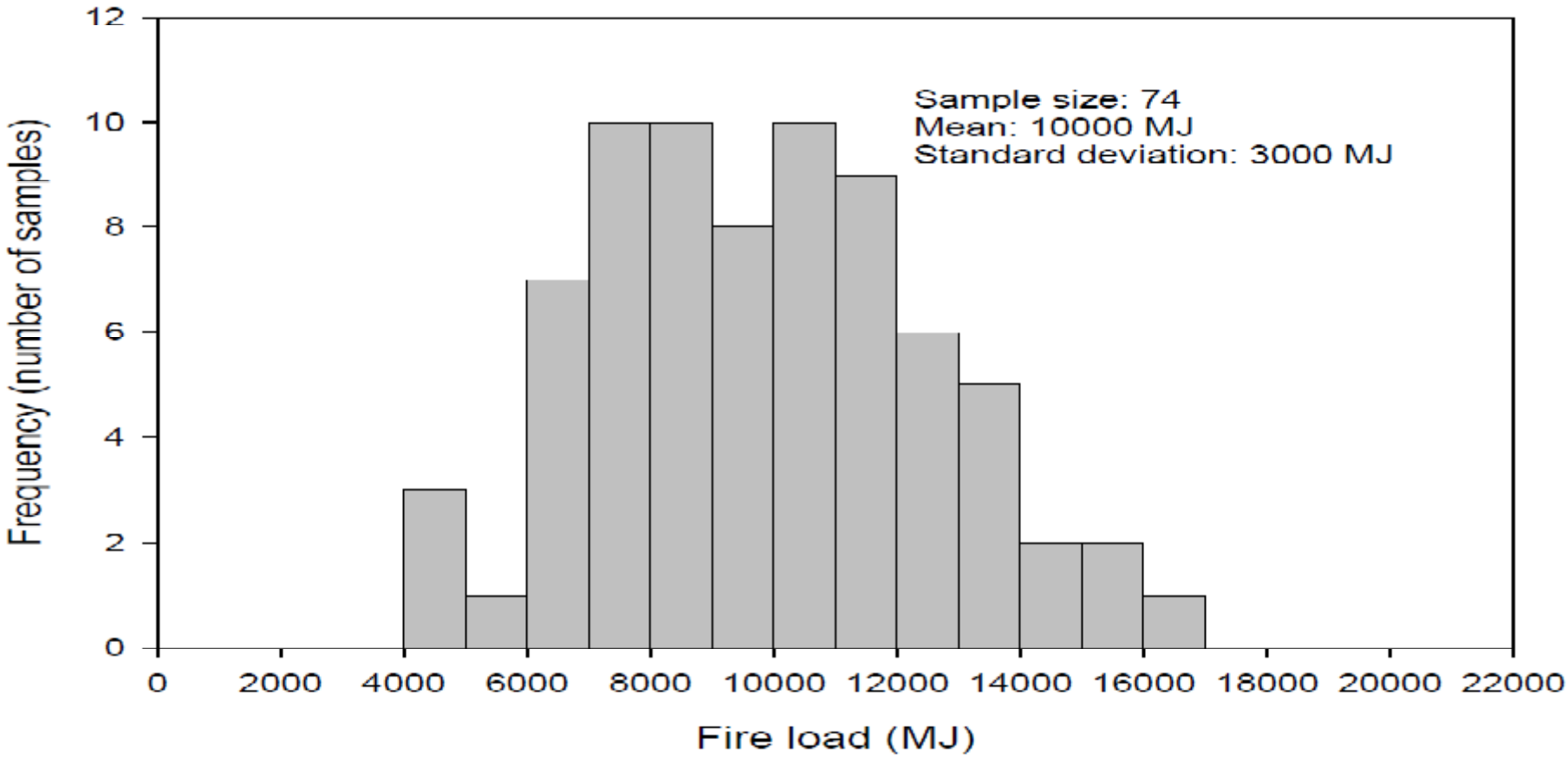


Peak Heat Release Rates

- **CFBT Container Simulation - 1.5MW**
- Sofa (2-seater) - 3.0MW
- Sofa (3-seater) - 3.5MW
- Upholstered Chair - 2.0MW
- Rubbish Bin (small) - 300KW
- Light Bulb - 100W
- Xmas Tree - 0.7MW
- Small Dresser - 1.8MW
- Single Mattress - 1.0MW
- Pine Bunk Beds - 4.5MW
- 5 Timber Pallets - 1.8MW
- 2 Panel Work Station - 1.8MW
- TV & Video with 40 VHS tapes – 4MW
- Kings Cross Fire - 15-25MW

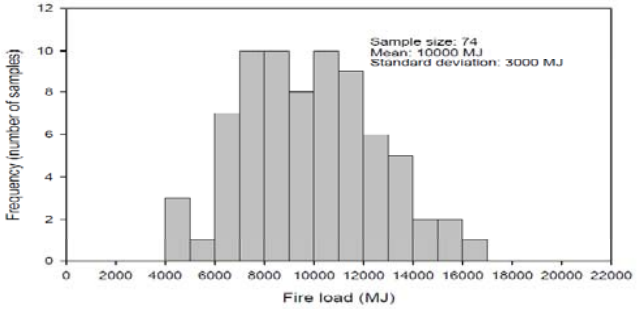
- NIST wind driven flat fire simulation (25mph) 16.7 MW

FUEL: Loading



2007 study by NRCC Building research

FUEL: Loading



Potential fuel load 10,000 MJ

So if this buildings contents burnt un-aided for 60 mins it would liberate a constant average of 2.7 MW of energy