# Kent & East Sussex Railway

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# Heat and Steam

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**Version: 1 Date: 13/10/2014**

**Heat**

In its simplest form the steam locomotive is a mobile power plant. It has four main processes that occur to make the locomotive move:-

1. Fuel and combustion.
2. Creating Steam
3. Utilising Steam
4. The Driving Mechanism.

Heat is a form of energy, when the coal burns in the firebox its heat energy is capable of being expressed in terms of useful work. These high temperatures attained in the firebox by the combustion of the fuel vary according to the conditions and may reach a maximum of 3000°F (1649°C). The heat generated is transferred to the water in the boiler through the firebox plates and tubes where it is converted to pressure energy in the form of steam, the steam in turn being led to the cylinders where it is transformed into mechanical energy and through the medium of the driving mechanism results in the tractive effort of the locomotive.

There are three ways in which heat can be transferred from one item to another;

**Conduction;**

Heat passes from one body to another by contact as warmer particles impart their heat to colder particles. In a locomotive boiler, the tubes transfer heat from the hot gasses to the water through the metal by conduction.

**Convection;**

Convection is the movement caused in a liquid or gas by the tendency of hotter, less dense material to rise and cooler, denser material to fall under the influence of gravity allowing for heat to be transferred. In a locomotive boiler the hot gasses in the firebox transfer their heat from the fire by convection to other metal surfaces within the boiler. Likewise in the water spaces convection currents circulate the water and transfer heat throughout the boiler.

**Radiation;**

The fire in a locomotive firebox gives off energy in the form of radiant heat. Heat radiated may be reflected, absorbed or transmitted. For example, the heat in the firebox crown sheet is absorbed from heat radiated from the fire before being transferred into the water by conduction.

**Making steam under pressure**

When enough heat is applied to water it raises the water temperature to boiling point and creates steam. This steam being enclosed within the boiler cannot escape. If the application of heat is continued to the water more and more steam is produced. This steam is elastic in nature and becomes compressed as it decreases in volume as the pressure increases. This pressure also acts on the water, increasing the amount of energy required to turn it from water to steam. This means that the higher the pressure rises, the more energy is required to break the bonds in the water molecules and turn it into steam.

**Saturated Steam**

The steam collected directly above the water in a locomotive boiler is called saturated steam, or 'wet' steam. The temperature of this steam varies according to the boiler pressure as show the table below:

| Gauge Pressure in lb per sq. in. | Temperature °F | Temperature °C |
|---|---|---|
| 0 | 212.0 | 100 |
| 50 | 297.9 | 147.7 |
| 100 | 337.8 | 169.8 |
| 120 | 350.0 | 176.6 |
| 130 | 355.5 | 179.7 |
| 140 | 360.8 | 182.8 |
| 150 | 365.8 | 185.4 |
| 160 | 370.6 | 188.1 |
| 165 | 372.9 | 189.4 |
| 170 | 375.2 | 190.6 |
| 175 | 377.4 | 191.8 |
| 180 | 379.6 | 193.1 |
| 185 | 381.7 | 194.3 |
| 190 | 383.8 | 195.4 |
| 195 | 385.9 | 196.6 |
| 200 | 387.9 | 197.7 |

**Superheated Steam**

Should the steam be heated further whilst in contact with the water in the boiler it will result in more saturated steam being produced until such a time that the safety valves lift to vent the excess steam. However should the steam be heated again away from the boiler water the steam will turn into superheated steam and its temperature rise further. This transformation normally occurs on superheated locomotives whilst the steam is in the steam circuit between the regulator valve and the steam chest. Superheated steam is normally around 600°F (315.5°C) –750°F (399°C)depending on the design of superheater and the way the engine is being worked.

Superheated steam has three main advantages;

- Any droplets of water carried over into the steam circuit are turned into steam.
- Cylinder condensation is reduced.
- The volume of superheated steam is 30% greater than saturated steam. This means that the demand on the boiler to produce steam is reduced and the operation of the boiler is more efficient with a saving in water and coal.

Superheater designs vary but usually follow a common principle. Please the separate handout on Superheaters for more information.