TRAINING ON BOILERS

PRESENTED AT

M/S. MAGADI SODA COMPANY ,
MAGADI , KENYA

WHAT IS A BOILER ?

- BOILER IS AN EQUIPMENT WHICH PRODUCES STEAM AT THE REQUIRED PRESSURE AND TEMPERATURE .
- BOILER DESIGN , MANUFACTURE & INSTALLATION ARE GOVERNED BY LAWS IN MOST OF THE COUNTRIES.
- INSPECTION AGENCIES CONTROL & IMPLEMENT THIS LAW TO ENSURE SAFETY TO THE PUBLIC.

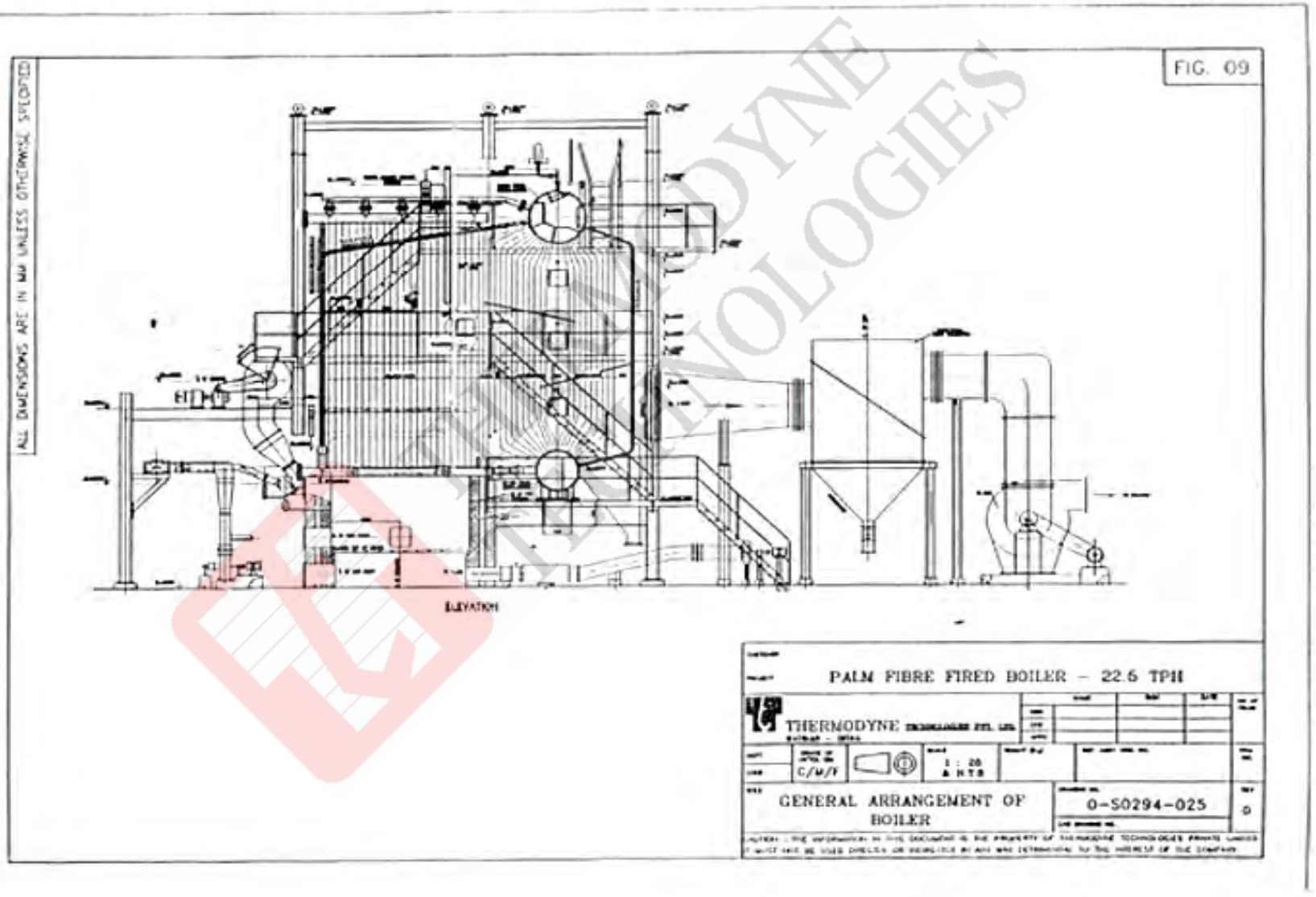
BOILER CLASSIFICATIONS

- USE OF STEAM : UTILITY OR POWER/PROCESS OR INDUSTRIAL
- ASSEMBLY :SHOP ASSEMBLED/SITE ASSEMBLED
- NATURE OF SUPPORT : BOTTOM / TOP
- STEAM CONDITION: SATURATED/SUPERHEATED
- FIRING SYSTEM : BURNERS/FIXED GRATE/ DUMPING GRATE/ RECIPROCATING GRATE/ TRAVELING GRATE/ PULVERISED/FLUIDISED BED

BOILER CLASSIFICATIONS - CONTINUED

- TUBE SIDE MEDIUM :SMOKE TUBE/ WATER TUBE/ COMPO
- FUEL / HEAT SOURCE : COAL / OIL / GAS / BIO-MASS / WASTE HEAT
- CONSTRUCTION : BI-DRUM,SINGLE DRUM, MULTI-DRUM , SHELL & TUBE
- INSTALLATION : OUT DOOR / IN DOOR
- CIRCULATION : NATURAL / FORCED/ONCE THRO'
- DRAFT: NATURAL/FORCED/INDUCED/BALANCED

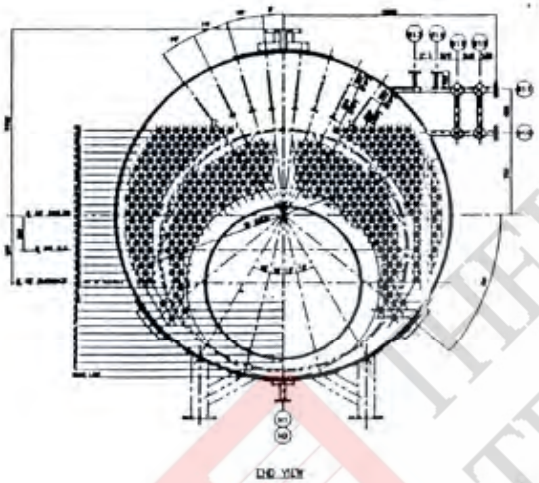
TYPICAL WATER TUBE BOILER



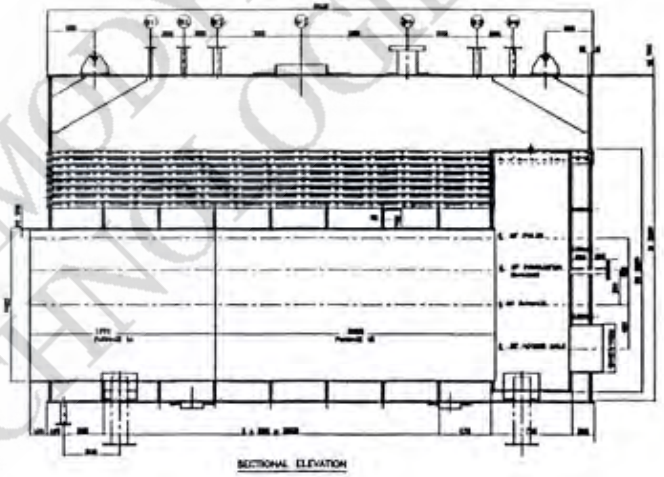
3 PASS WET BACK SHELL & TUBE BOILER

ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE SPECIFIED

FIG. 11



END VIEW



SECTIONAL ELEVATION

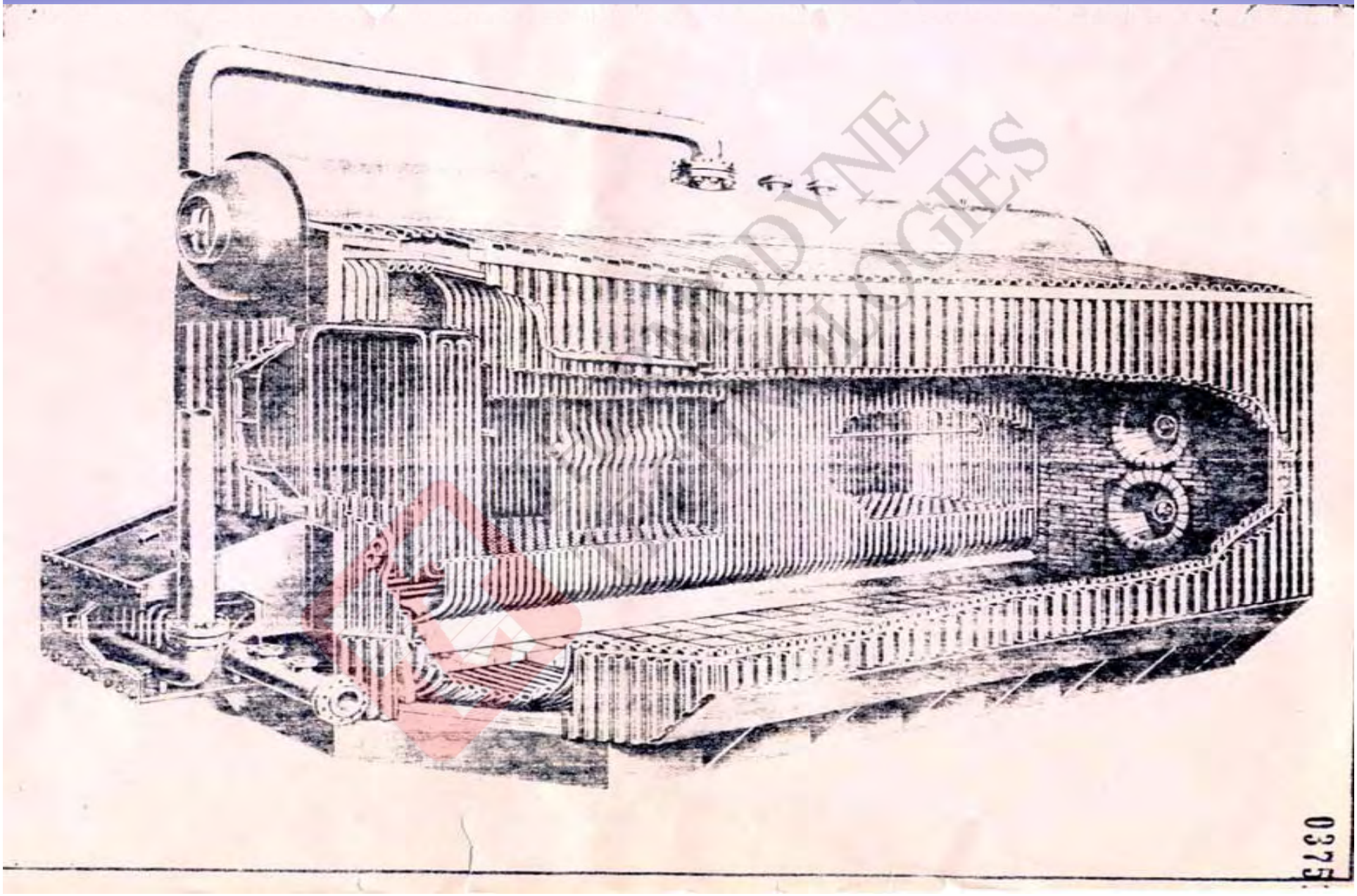
THERMODYNE TECHNOLOGIES PVT. LTD.
CHENNAI – INDIA

	NAME	SIGN.	DATE
DRN.			
CHD.			
APPD.			

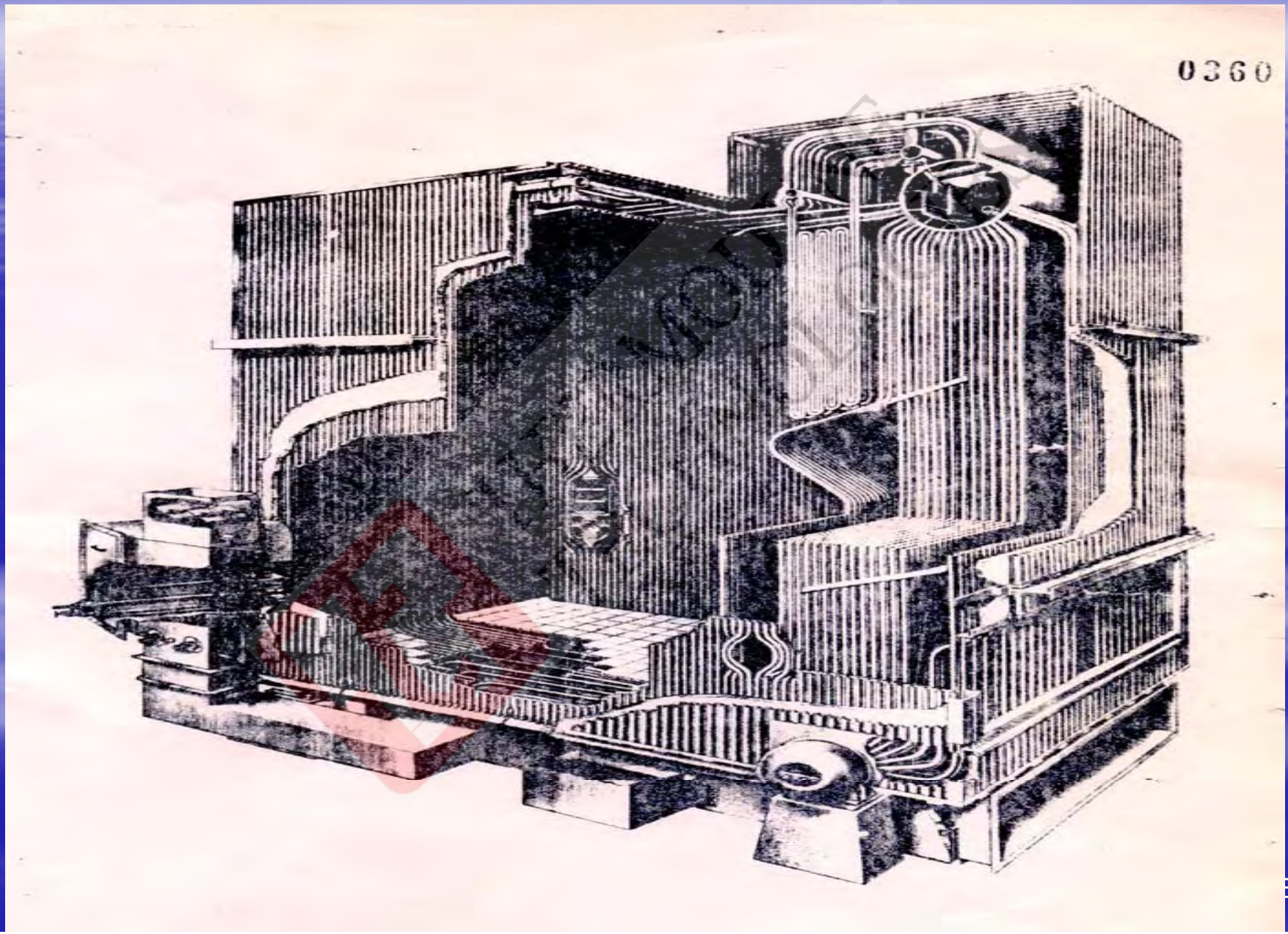
TITLE

PRESSURE PART ARRANGEMENT FOR
HORIZONTAL MULTITUBULAR 3 PASS WET BACK BOILER

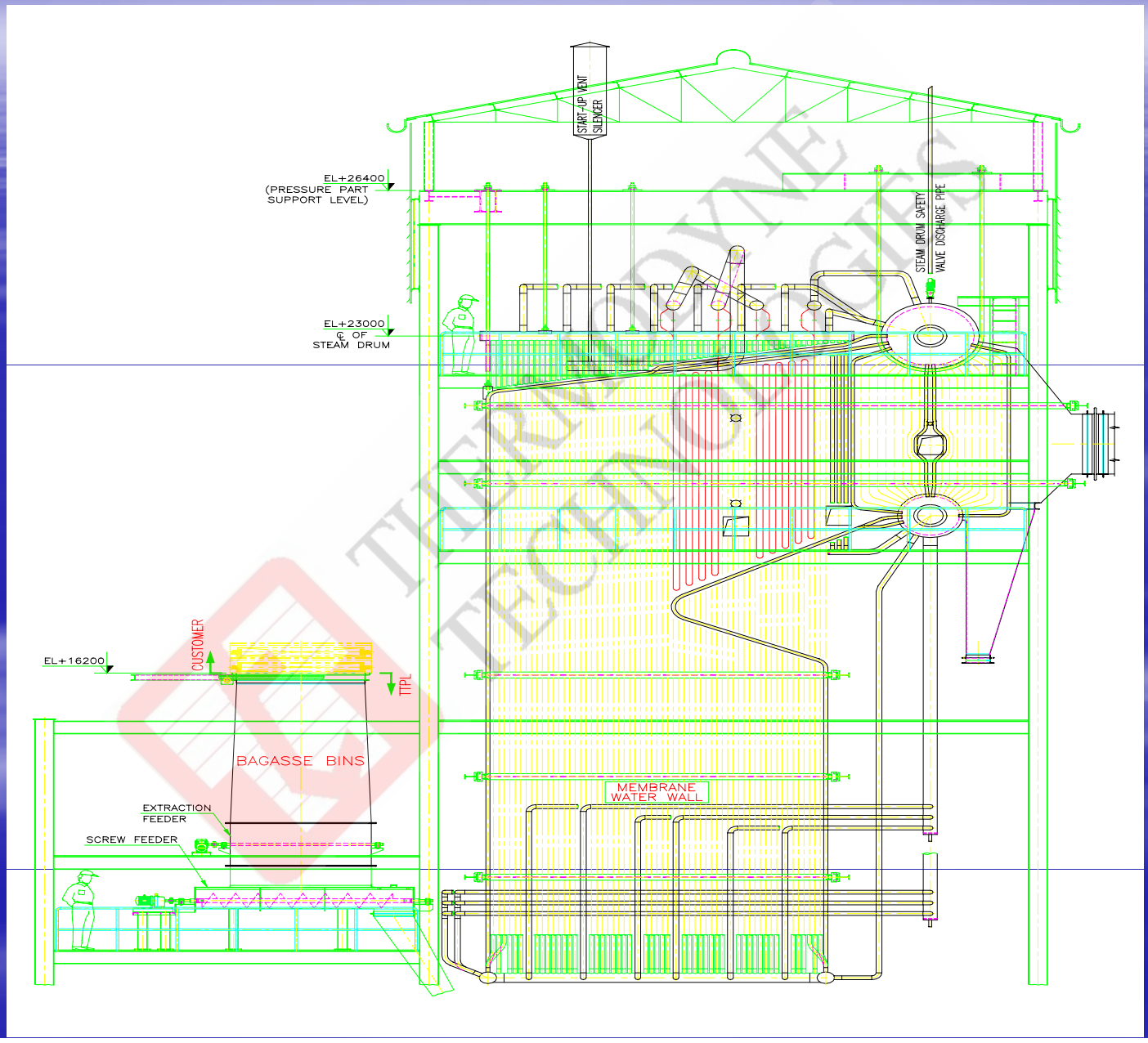
‘D’ TYPE OIL & GAS FIRED BOILER



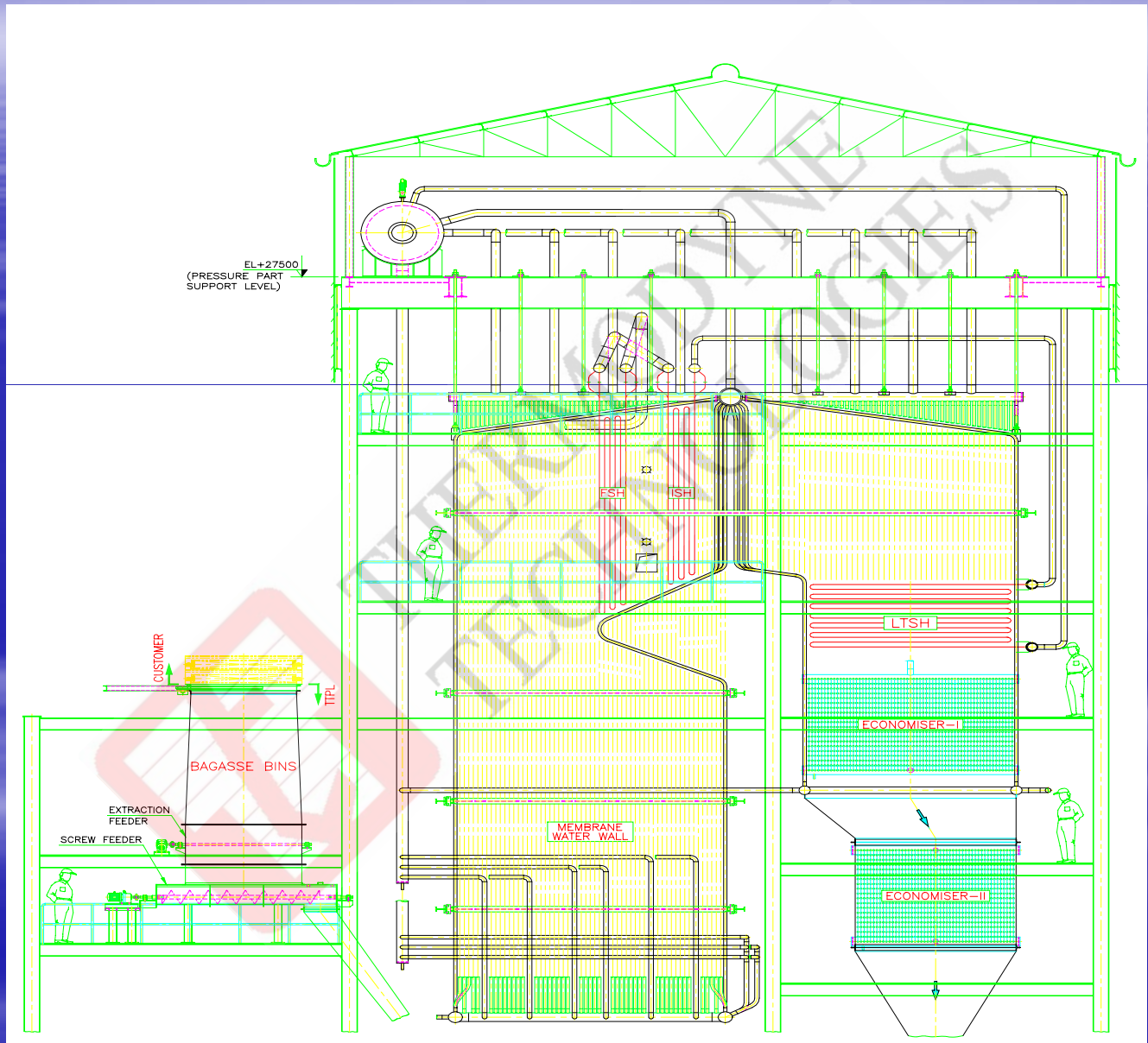
TYPICAL MEDIUM SIZE OIL & GAS FIRED BOILER



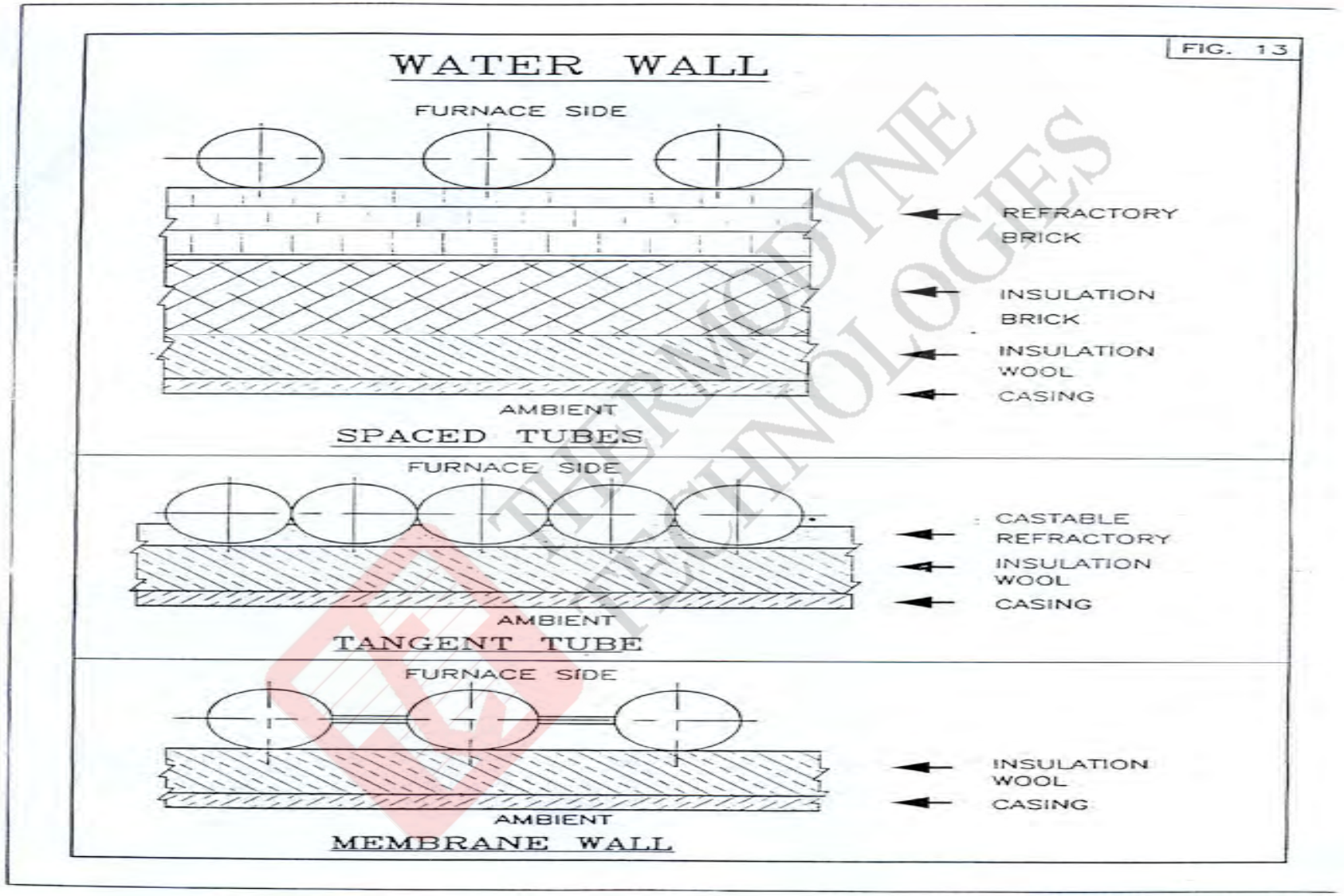
TYPICAL LARGE BI-DRUM INDUSTRIAL BOILER



SINGLE DRUM INDUSTRIAL BOILER



TYPES OF WATER WALL CONSTRUCTION



DESIGN INPUTS

- BOILER PARAMETERS
- CAPACITY, STEAM OUTLET PRESSURE , STEAM OUTLET TEMPERATURE , FEED WATER INLET TEMPERATURE
- FUEL CHARACTERSTICS
- BOILER EFFICIENCY
- AMBIENT CONDITIONS
- OTHER STATUTORY AND AUXILIARY STIPULATIONS

AMBIENT CONDITIONS

- AMBIENT TEMPERATURE
- RELATIVE HUMIDITY
- SITE ELEVATION
- SEISMIC ZONE

BOILER EFFICIECY

BOILER EFFICIENCY = OUTPUT/INPUT

ALTERNATIVELY

BOILER EFFICIECY = (INPUT-LOSSES)/INPUT

LOSSES IN A BOILER

- DRY GAS LOSS : ENTHALPY DIFFERENCE BETWEEN FLUE GAS LEAVING BOILER AND AMBIENT AIR MULTIPLIED BY DRY FLUE GAS QUANTITY
- FUEL MOISTURE LOSS : HEAT TAKEN BY THE FUEL MOISTURE TO BECOME WATER VAPOUR
- MOISTURE DUE TO COMBUSTION OF HYDROGEN LOSS : EVERY UNIT OF HYDROGEN IN FUEL PRODUCES 9 UNITS OF MOISTURE. HEAT TAKEN BY THIS MOISTURE TO BECOME WATER VAPOUR

LOSSES IN A BOILER – CONTINUED

- AIR MOISTURE LOSS : ENTHALPY DIFFERENCE IN MOISTURE BROUGHT IN BY COMBUSTION AIR BETWEEN FLUE GAS TEMPERATURE AND AMBIENT TEMPERATURE
- UNBURNT CARBON LOSS : HEAT LOST DUE TO INCOMPLETE COMBUSTION OF CARBON IN FUEL
- RADIATION LOSS : HEAT LOSS FROM BOILER EXTERNAL SURFACE TO ATMOSPHERE

LOSSES IN A BOILER – CONTINUED

- UNACCOUNTED LOSSES : SMALL LOSSES WHICH CAN NOT BE ACCURATELY CALCULATED LIKE HEAT LOSS IN BLOW DOWN WATER , HEAT GOING WITH ASH , HEAT LOSS BY RADIATION FROM BOILER OPENINGS ETC.
- MANUFACTURER'S MARGIN

BOILER EFFICIENCY

CONSIDERATIONS

- INITIAL COST Vs. RUNNING FUEL COST
- ENERGY CONSERVATION
- WASTE FUEL UTILIZATION

GOVERNING FACTORS

- EXCESS AIR
- FLUE GAS OUTLET TEMP.
- MOISTURE AND HYDROGEN CONTENT IN FUEL
- AMBIENT TEMP. AND MOISTURE
- COMPLETENESS OF COMBUSTION
- EFFECTIVENESS OF INSULATION

BOILER EFFICIENCY ON GCV & NCV

BOILER EFFICIENCY ON NCV = BOILER EFFICIENCY ON GCV X GCV/NCV

THE DIFFERENCE IN EFFICIENCY IS THE HEAT LOSS DUE MOISTURE IN FUEL

GCV : GROSS CALORIFIC VALUE

NCV : NET CALORIFIC VALUE

HEAT ADDITION IN BOILER

THREE TYPES OF HEAT IS ADDED TO FEED WATER IN THE BOILER TO CONVERT THE SAME TO STEAM. THEY ARE :

- SENSIBLE HEAT UPTO BOILING POINT
- LATENT HEAT TO CONVERT LIQUID PHASE WATER TO VAPOUR PHASE STEAM
- SENSIBLE HEAT ADDITION TO RAISE THE STEAM TEMPERATURE FROM SATURATION TO THE DESIRED SUPER HEAT TEMPERATURE

STEAM BOILING

- STEAM BOILS AT ITS SATURATION TEMPERATURE
- BOILING TEMPERATURE OF WATER AT AMBIENT CONDITION IN SEA LEVEL IS 100 DEG.C
- BOILING TEMPERATURE INCREASES WITH PRESSURE
- LATENT HEAT DECREASES WITH PRESSURE

MAIN COMPONENTS OF BOILER

- FURNACE - FUEL IS BURNT AND HEAT IS RELEASED. HEAT ABSORPTION IS BY RADIATION TO ADD PART OF SENSIBLE HEAT & LATENT HEAT TO WATER
- SUPER HEATER - SUPER HEAT ABOVE SATURATION IS ADDED
- BOILER BANKS OR EVAPORATOR – PART OF SENSIBLE HEAT & LATENT HEAT IS ADDED
- ECONOMISER – SENSIBLE HEAT IS ADDED TO WATER TO TAKE IT CLOSE TO SATURATION TEMPERATURE

MAIN COMPONENTS OF BOILER - CONTINUED

- AIR HEATER – HEATS THE INCOMING COMBUSTION AIR BY THE OUTGOING HOT GAS THUS INCREASING BOILER EFFICIENCY
- STEAM DRUM :
- STEAM FROM STEAM-WATER MIXTURE FROM FURNACE & EVAPORATOR IS SEPERATED
- HOLDS ENOUGH WATER VOLUME TO PROTECT BOILER FURNACE TUBES IN THE EVENT OF BOILER TRIP

SUPER HEATER TYPES

- BY THE MAJOR TYPE OF HEAT RECEIPT
  - RADIANT SUPER HEATER
  - CONVECTIVE SUPER HEATER
- BY ORIENTATION
  - HORIZONTAL , FULLY DRAINABLE
  - VERTICAL , NON- DRAINABLE
- BY ARRANGEMENT
  - IN-LINE
  - STAGGERED
- BY FLOW OF GAS AND STEAM
  - PARALLAL FLOW
  - COUNTER FLOW

TYPES OF ECONOMISER

- BY ORIENTATION
  - HORIZONTAL
  - VERTICAL
- BY ARRANGEMENT
  - IN-LINE
  - STAGGERED
- TYPE OF TUBE
  - PLAIN TUBE
  - FINNED TUBE

STEAMING ECONOMISERS WILL CAUSE HAMMERING AND HENCE TO BE AVOIDED. AN APPROACH POINT (TEMPERATURE DIFFERENCE BETWEEN FEED WATER LEAVING ECONOMISER AND SATURATION TEMPERATURE)OF MINIMUM 30 DEG.C SHALL BE PROVIDED

TYPES OF AIR HEATERS

- TUBULAR AIR HEATERS
- HEAT EXCHANGE ACROSS TUBES FROM GAS TO AIR
- AIR HEATER IS STATIONARY
- USED FOR INDUSTRIAL BOILERS
- ROTATING AIR HEATERS
- ELEMENTS HEATED AND COOLED BY THE GAS AND AIR RESPECTIVELY AS IT MOVES THROUGH THEM
- CONTINUOUSLY ROTATING
- MORE COMPACT FOR LARGE SIZE BOILERS

BOILER AUXILIARIES

- BOILER FEED PUMPS :
- SUPPLIES WATER TO BOILER
- SUSTAINS BOILER PRESSURE BY PUMPING AGAINST OPERATING PRESSURE
- FAILURE OF FEED PUMP RESULTS IN BOILER TRIP & HENCE STANDBY ESSENTIAL
- MULTI-STAGE CENTRIFUGAL PUMPS ARE GENERALLY USED
- NORMALLY DRIVEN BY ELECTRIC MOTOR. STEAM TURBINE DRIVE CAN BE USED
- FLOW CONTROL IS BY OUTLET CONTROL VALVE
- TO SAVE POWER VARIABLE SPEED DRIVES ARE USED

BOILER AUXILIARIES - CONTINUED

- FANS :
- PROVIDES COMBUSTION AIR
- EVACUATES FLUE GAS TO CHIMNEY
- GENERALLY CENTRIFUGAL FANS ARE USED
- AXIAL FANS MAY BE USED IN LARGE BOILERS FOR FD FAN
- NORMALLY DRIVEN BY ELECTRIC MOTOR. STEAM TURBINE DRIVE CAN BE USED
- NORMALLY CONTROLLED BY INLET GUIDE VANE/DAMPER
- TO SAVE POWER VARIABLE SPEED DRIVES ARE USED

DUST COLLECTORS

- MECHANICAL DUST COLLECTOR
- CAN BE SINGLE OR MULTI-CONE
- DUST COLLECTION EFFICIENCY BETWEEN 90 TO 95 %
- DUST SEPERATES DUE TO CENTRIFUGAL ACTION
- GOOD FOR LARGE PARTICLE SIZES
- DRAFT LOSS AROUND 75 MMWC

DUST COLLECTORS - CONTINUED

- WET SCRUBBERS :
- USES MOISTURE TO CAPTURE DUST
- USED IN BOILERS USING LOW ASH FUELS LIKE BAGASSE
- WATER IS AN ESSENTIAL PRE-REQUISITE
- DRAFT LOSS 75 TO 100 MMWC
- CONVERTS AIR POLLUTION TO WATER POLLUTION

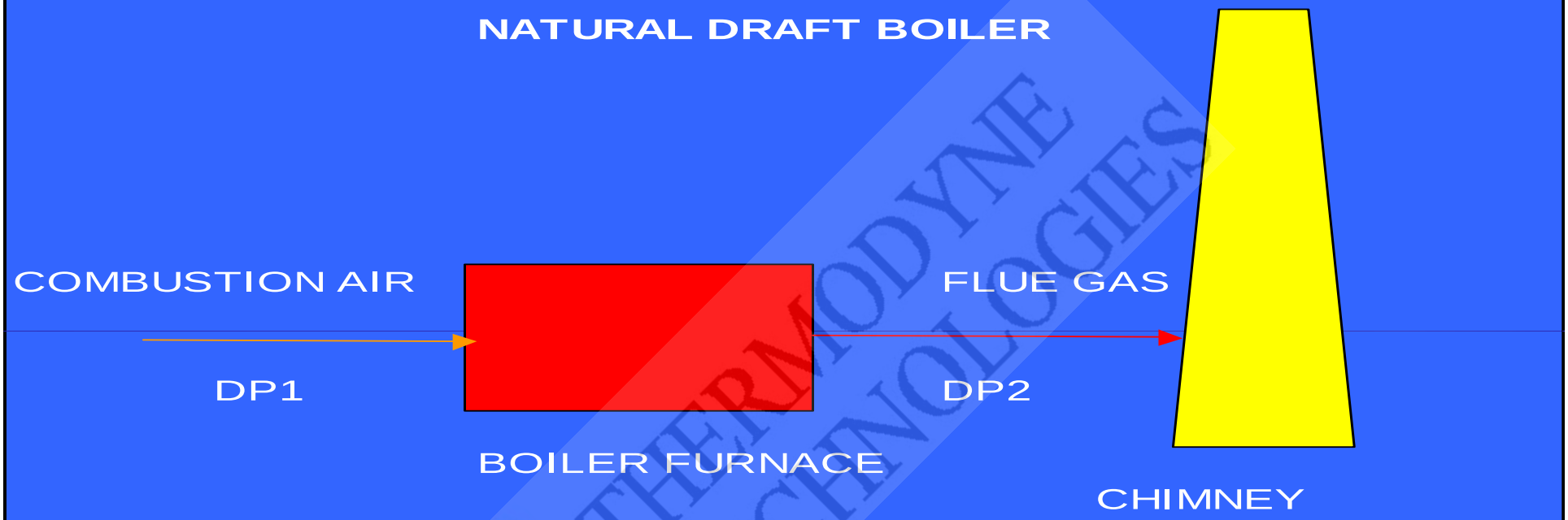
DUST COLLECTORS - CONTINUED

- ELECTRO-STATIC PRECIPITATORS
- IONISES THE GASES AND DUST CAPTURED ON THE CATHODES
- EFFICIENCY AS HIGH AS 99.9%
- CAN CAPTURE FINER DUST
- DRAFT LOSS ONLY 25 MMWC
- HIGH POWER CONSUMPTION AS ELEMENTS TO BE ELECTRICALLY CHARGED
- USED FOR LARGE SOLID FUEL FIRED BOILERS AND CEMENT PLANTS

DUST COLLECTORS - CONTINUED

- BAG FILTERS :
- USES CLOTH AS FILTERS
- GENERALLY USED IN LOW EROSIVE DUST
- EFFICIENCY ABOVE 99.9%
- HIGH DRAFT LOSS 75 TO 150 MMWC AND HENCE HIGH ID FAN POWER CONSUMPTION
- BAGS NEED MAINTENANCE AND REPLACEMENT EVEN THOUGH POWER CONSUMPTION IS LESSER THAN ESP

DRAFT SYSTEMS IN BOILERS



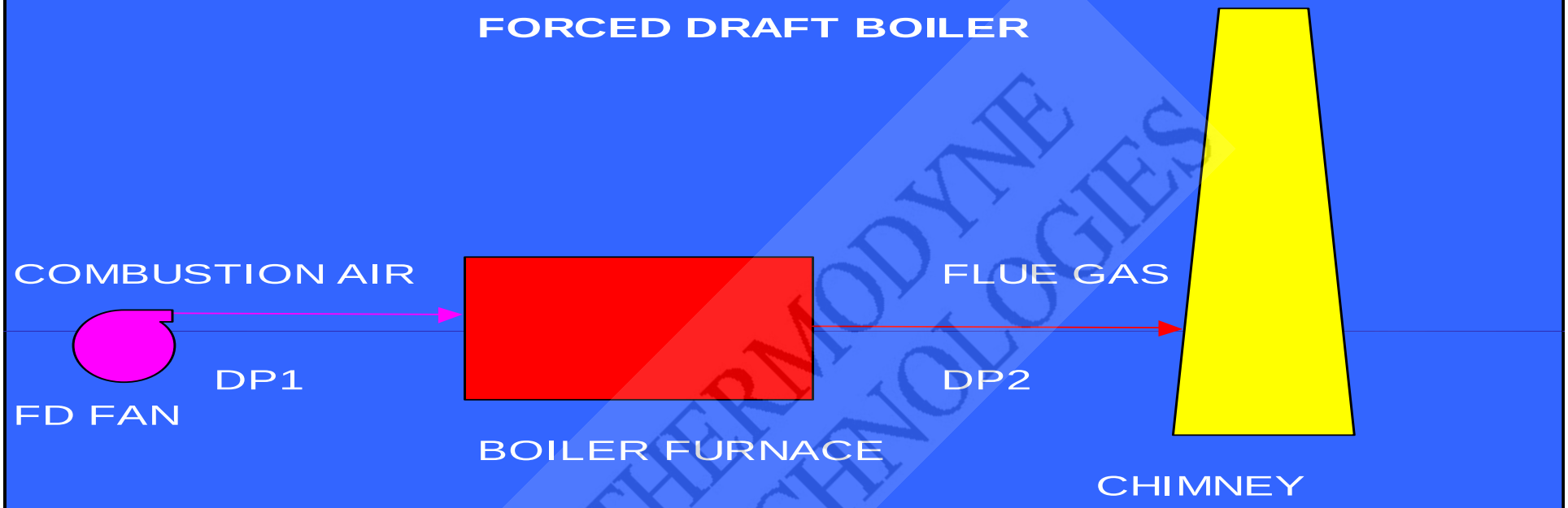
USED FOR VERY SMALL BOILERS

NATURAL DRAFT OF CHIMNEY = DP1+DP2

DP1 , DRAFT LOSSES UPTO FURNACE

DP2 , DRAFT LOSSES FROM FURNACE UPTO CHIMNEY

DRAFT SYSTEMS -COMTINUED



USED FOR MEDIUM SIZE OIL & GAS FIRED BOILERS

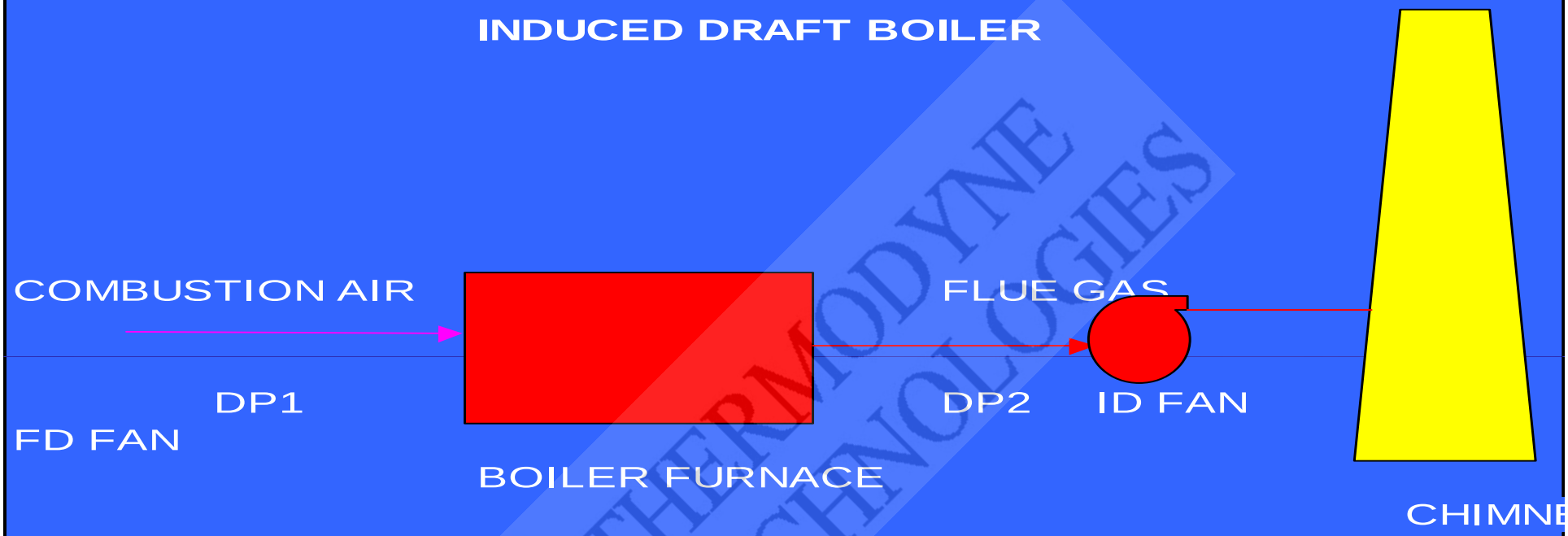
HEAD OF FD FAN = DP1+DP2

FURNACE & BOILER WILL BE UNDER POSITIVE PRESSURE

DP1 , DRAFT LOSSES UPTO FURNACE

DP2 , DRAFT LOSSES FROM FURNACE UPTO CHIMNEY

DRAFT SYSTEMS - CONTINUED



USED FOR SMALL & MEDIUM SIZE SOLID FUEL FIRED BOILERS

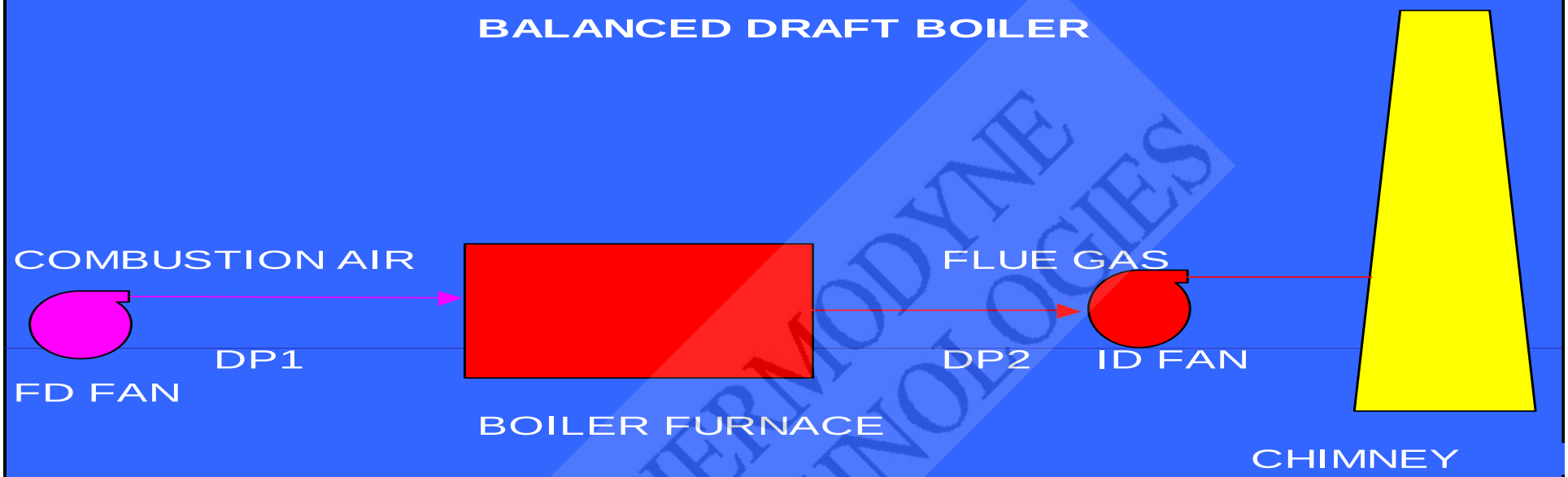
HEAD OF ID FAN = DP1+DP2

FURNACE & BOILER WILL BE UNDER NEGATIVE PRESSURE

DP1 , DRAFT LOSSES UPTO FURNACE

DP2 , DRAFT LOSSES FROM FURNACE UPTO CHIMNEY

DRAFT SYSTEMS - CONTINUED



USED FOR LARGE SIZE BOILERS

HEAD OF ID FAN = DP2

HEAD OF FD FAN = DP1

FURNACE UNDER NEAR ZERO (-5 TO -10 MMWC) PRESSURE

DP1 , DRAFT LOSSES UPTO FURNACE

DP2 , DRAFT LOSSES FROM FURNACE UPTO CHIMNEY

BOILER CIRCULATION SYSTEMS

- NATURAL CIRCULATION
- FORCED CIRCULATION
- ASSISTED FORCED CIRCULATION
- ONCE THROUGH BOILERS
- WHAT DOES GOOD CIRCULATION DO ?

➢ ESSENTIAL TO PROTECT THE FURNACE TUBES FROM OVER HEATING FAILURE

➢ TO KEEP THE EVAPORATION IN THE NUCLEATE BOILING RANGE

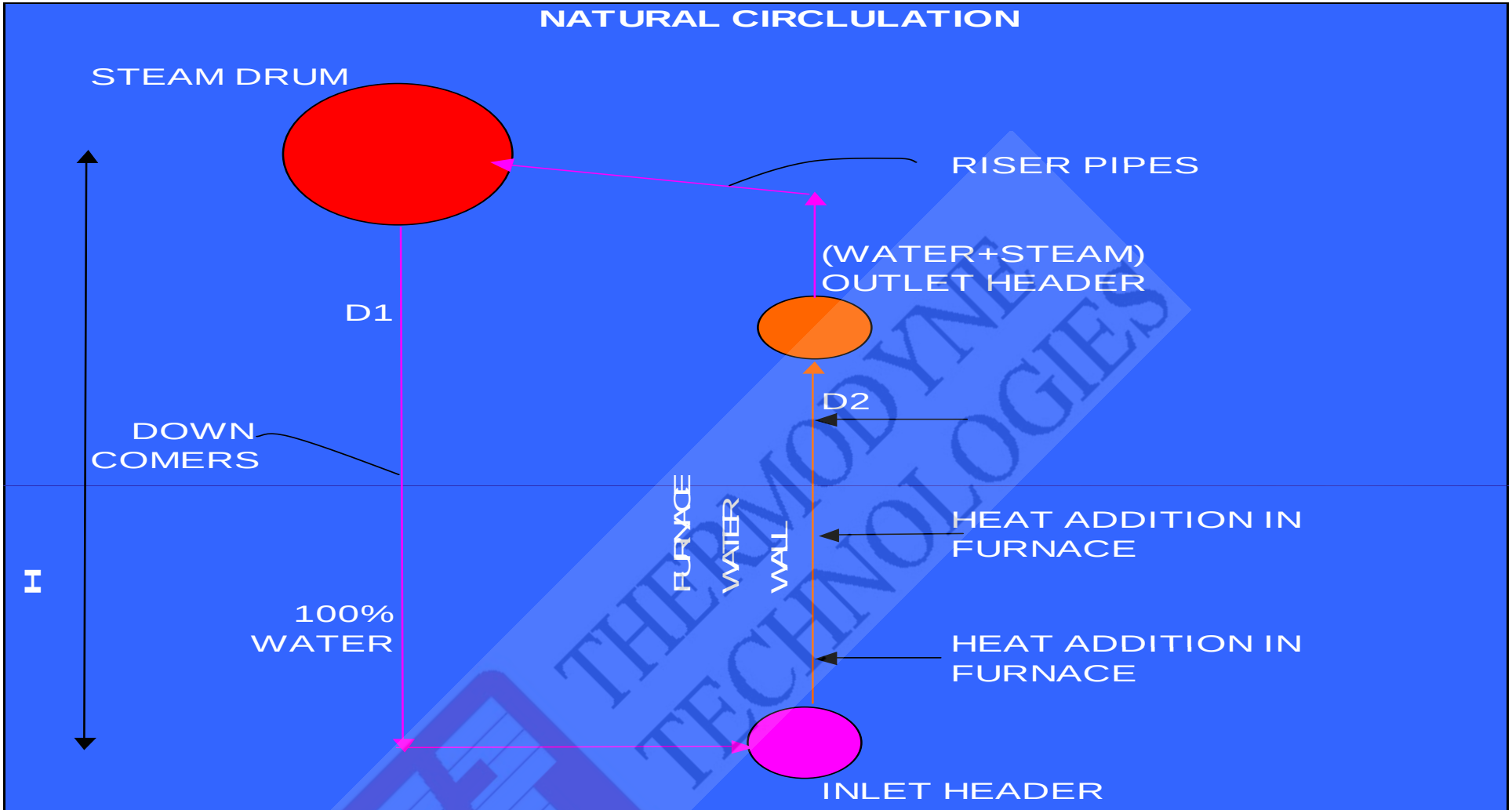
TYPES OF BOILING

- NUCLEATE BOILING
- LOWER HEAT FLUX
- ENSURES THAT ALWAYS WATER IS IN TOUCH WITH HEATING SURFACE AND THUS ENSURES GOOD COOLING
- BOUNDARY LAYER HEAT TRANSFER CO-EFFICIENT HIGHER AND TEMPERATURE DROP ACROSS BOUNDARY LAYER LARGER

TYPES OF BOILING - CONTINUED

- FILM BOILING
  - VERY HIGH HEAT FLUX
  - STEAM IN TOUCH WITH HEATING SURFACE & HENCE COOLING IS POOR
  - BOUNDARY LAYER HEAT TRANSFER CO-EFFICIENT LOWER AND LOWER TEMPERATURE DROP ACROSS THE BOUNDARY LAYER

NATURAL CIRCLULATION



H , HEIGHT DIFFERENCE BETWEEN STEAM DRUM AND BOTTOM HEADER

NATURAL CIRCULATION FORCE = H X (D1-D2) KG/m2

CIRCULATION RATIO = WATER FLOW AT INLET / STEAM FLOW AT OUTLET

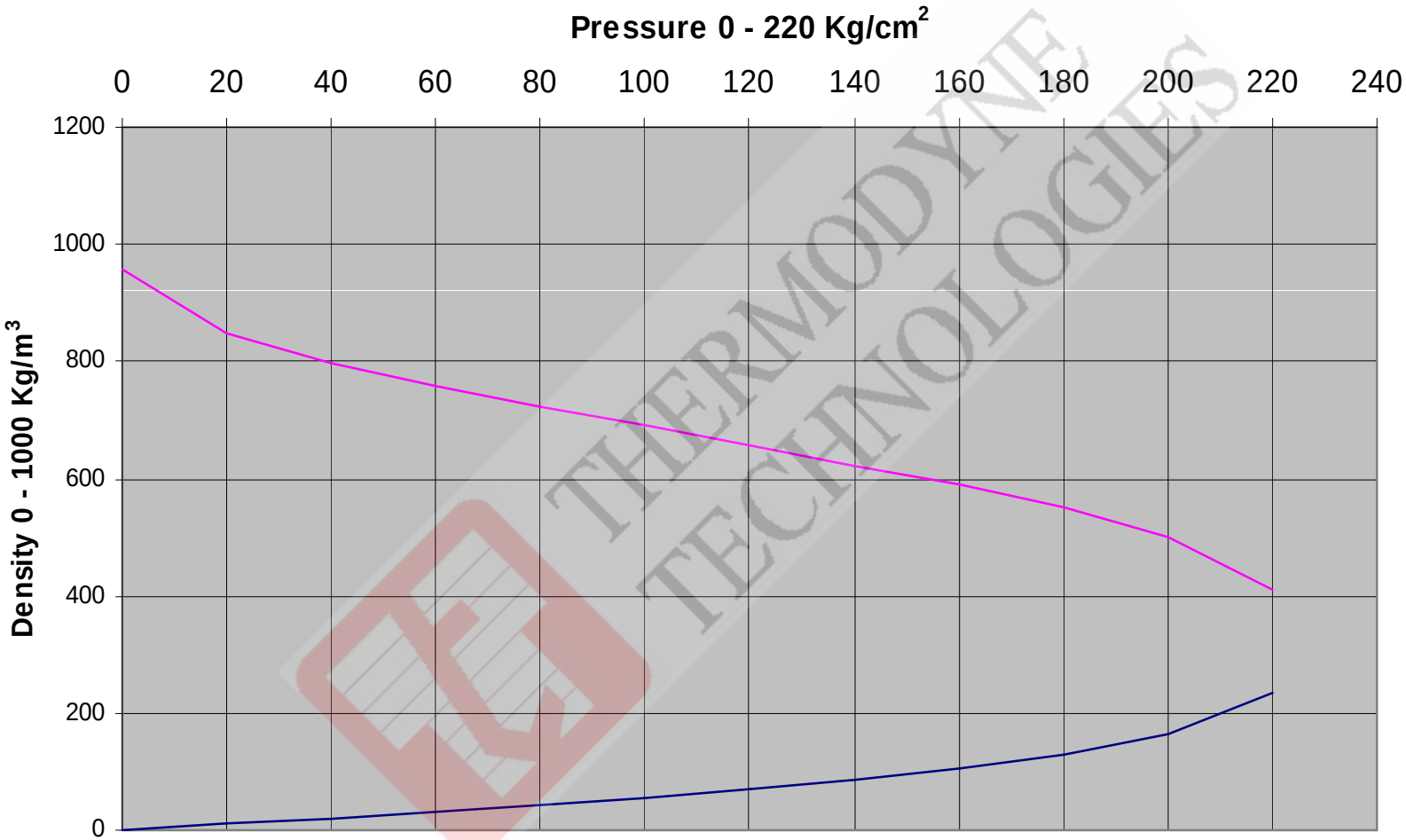
MINIMUM CIRCULATION RATIO FOR NATURAL CIRCULATION BOILERS IS 6 TO 8

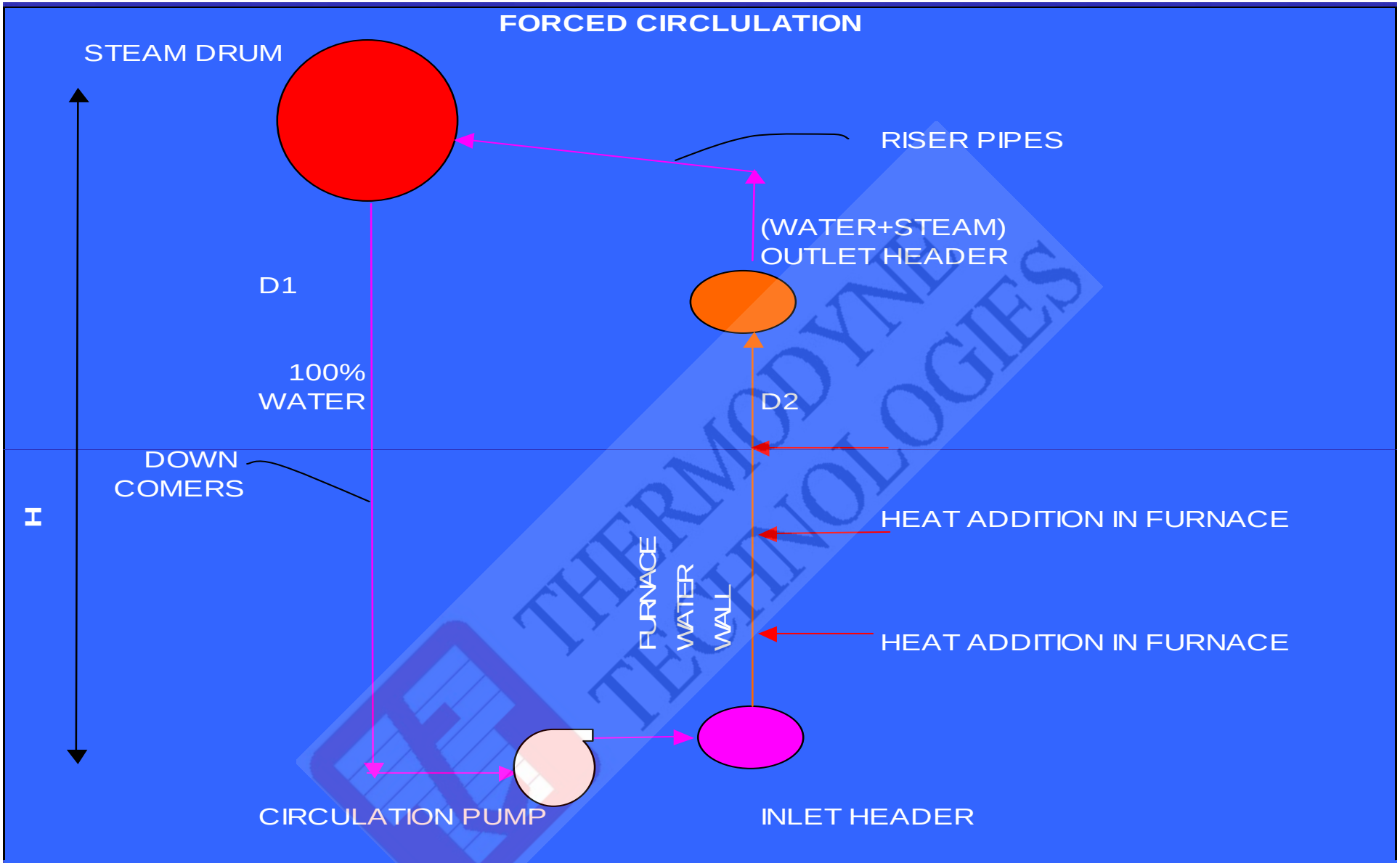
NATURAL CIRCULATION BOILERS ARE BUILT GENERALLY UP TO 150 KG/CM2(G) DRUM PRESSURES.

NATURAL CIRCULATION

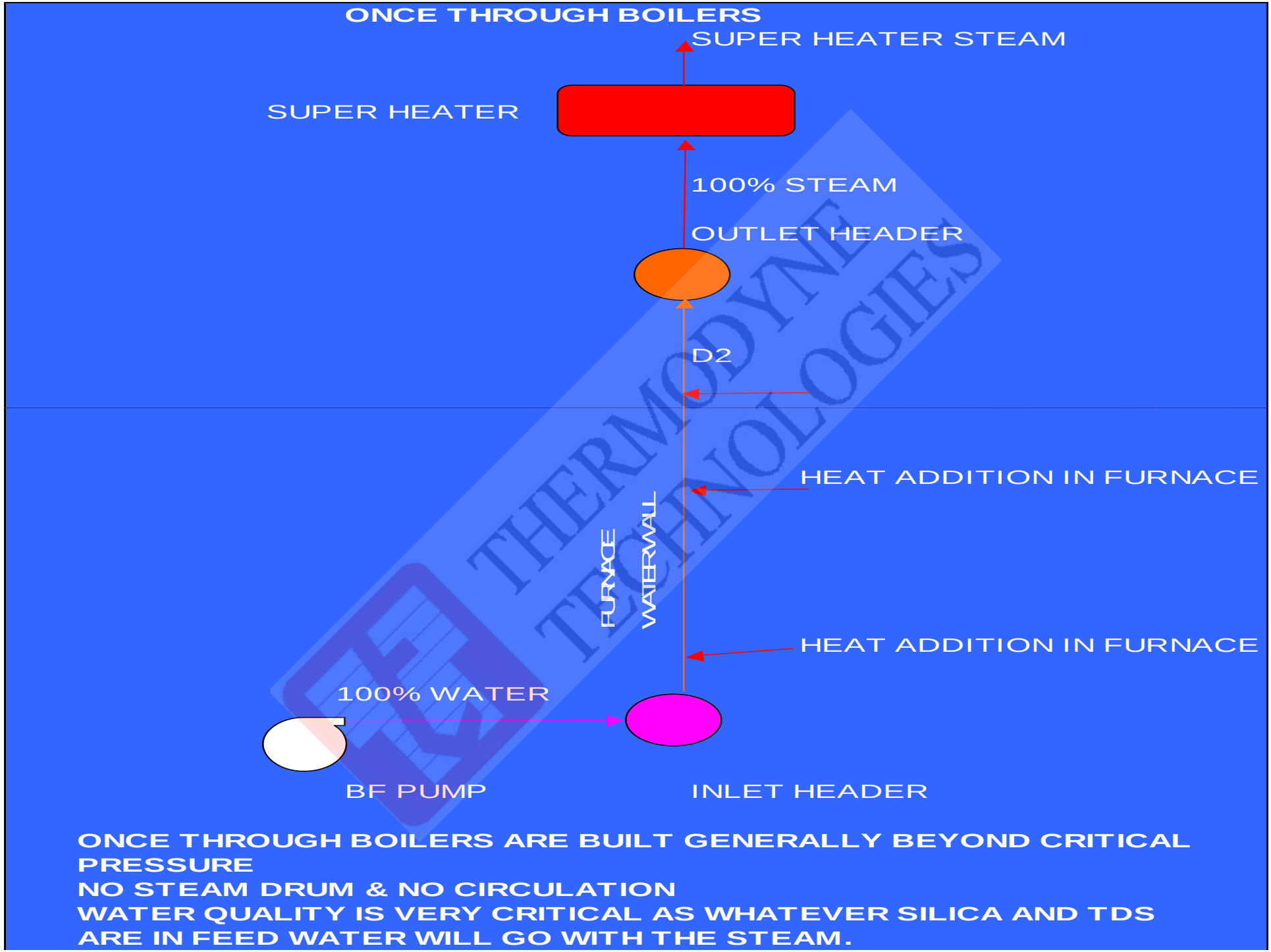
- MOTIVE FORCE FOR NATURAL CIRCULATION IS THE DENSITY DIFFERENCE BETWEEN THE WATER AND WATER STEAM MIXTURE
- THIS IS HIGH AT LOW PRESSURES AND LOW IN HIGH PRESSURE BOILERS DUE TO THE BEHAVIOR OF STEAM AND WATER DENSITIES WITH PRESSURE

STEAM WATER DENSITY CURVE





H , HEIGHT DIFFERENCE BETWEEN STEAM DRUM AND BOTTOM HEADER
CIRCULATION FORCE = H X (D1-D2) + PUMP HEAD KG/m2
CIRCULATION RATIO = WATER FLOW AT INLET / STEAM FLOW AT OUTLET
MINIMUM CIRCULATION RATIO FOR FORCED CIRCULATION BOILERS IS 3 TO 4
FORCED CIRCULATION BOILERS ARE BUILT GENERALLY BEYOND 150 KG/CM2(G) DRUM PRESSURES UP TO 200 KG/CM2(G)



ONCE THROUGH BOILERS ARE BUILT GENERALLY BEYOND CRITICAL PRESSURE

NO STEAM DRUM & NO CIRCULATION

WATER QUALITY IS VERY CRITICAL AS WHATEVER SILICA AND TDS ARE IN FEED WATER WILL GO WITH THE STEAM.

COMBUSTION CALCULATIONS

- $C + O_2 \longrightarrow CO_2 + HEAT$
- $2H_2 + O_2 \longrightarrow 2H_2O + HEAT$
- $S + O_2 \longrightarrow SO_2 + HEAT$
- I KG OF C REQUIRES 2.667 KG OF OXYGEN
- 1 KG OF H2 REQUIRES 8 KGS OF OXYGEN
- 1 KG OF SULPHUR REQUIRES 1 KG OF OXYGEN

COMBUSTION AIR

- STOICHIOMETRIC AIR IS THE QUANTITY OF AIR THEORETICALLY REQUIRED TO COMPLETE THE COMBUSTION OF FUEL
- PRACTICALLY STOICHIOMETRIC AIR QUANTITY IS NOT SUFFICIENT TO COMPLETE THE COMBUSTION DUE TO FUEL PARTICLE SIZE AND HOMOGENITY OF FUEL AND AIR IS NOT GOOD

EXCESS AIR

- EXCESS AIR IS THE QUANTUM OF AIR THAT IS REQUIRED OVER AND ABOVE STOICHIOMETRIC AIR QUANTITY TO HAVE SATISFACTORY COMPLETION OF COMBUSTION
- SOLID FUELS REQUIRE MORE EXCESS AIR THAN LIQUID FUELS
- LIQUID FUELS REQUIRE MORE EXCESS AIR THAN GASIOUS FUELS

TYPICAL EXCESS AIR LEVELS – SOLID FUEL FIRING

- FIXED GRATE / RECIPROCATING GRATE: 40 TO 50 %
- DUMPING GRATE : 35 TO 40 %
- TRAVELING GRATE : 35%
- TRAVELING GRATE WITH SPREADER STOKER : 30 TO 35 %
- FLUIDISED BED : 20 TO 25 %
- PULVERISED FUEL FIRING : 20%

TYPICAL EXCESS AIR LEVELS – LIQUID AND GASEOUS FUEL FIRING

- PRESSURE JET BURNERS : 15 TO 20%
- STEAM/AIR ATOMISED BURNERS : 10 TO 15%
- ROTARY CUP BURNERS : 10 TO 15%
- GAS BURNERS – NATURAL GAS : 5 TO 10%
- GAS BURNERS – LOW BTU GASES : 10 TO 15%