

Kawasaki

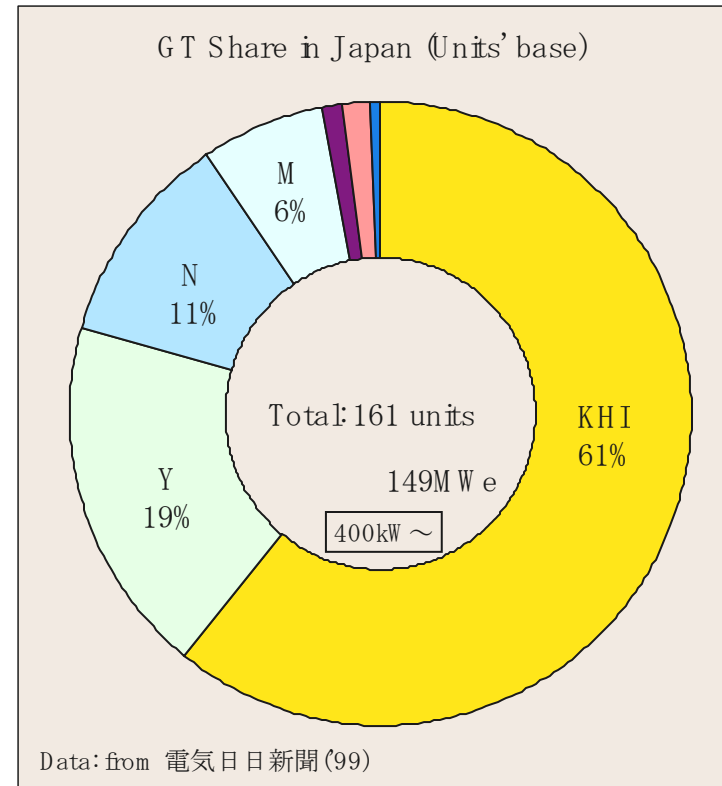
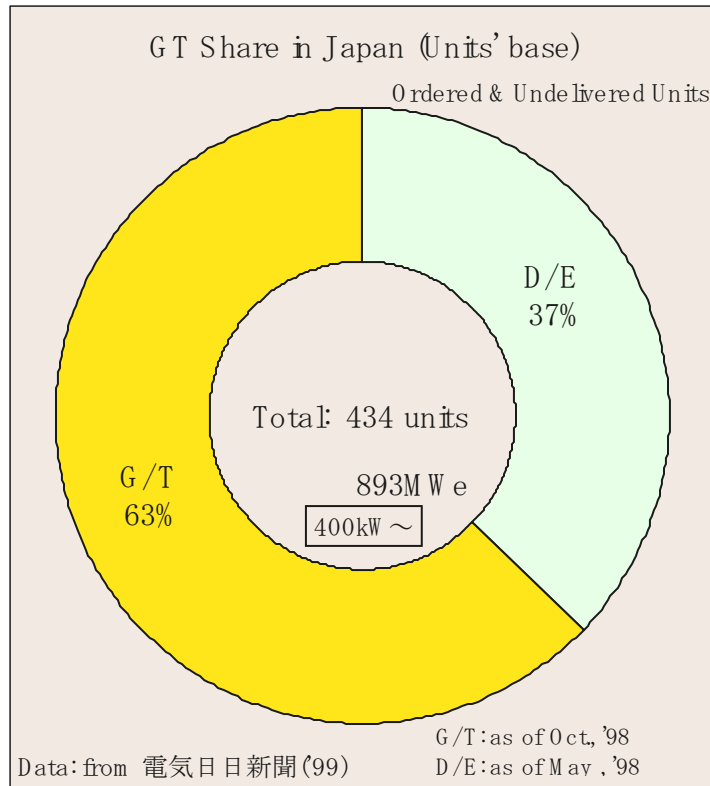
Gas Turbines

Gas Turbine Stand-by Generator Sets

-technical presentation-

**Kawasaki Gas Turbine-Americas
Houston, TX**

Installation Comparison of Gas turbine and Diesel engine in Japan



Gas turbine engine & generator set (external view, dimension, etc.)

● M1A(-01,-03,-06,-23)

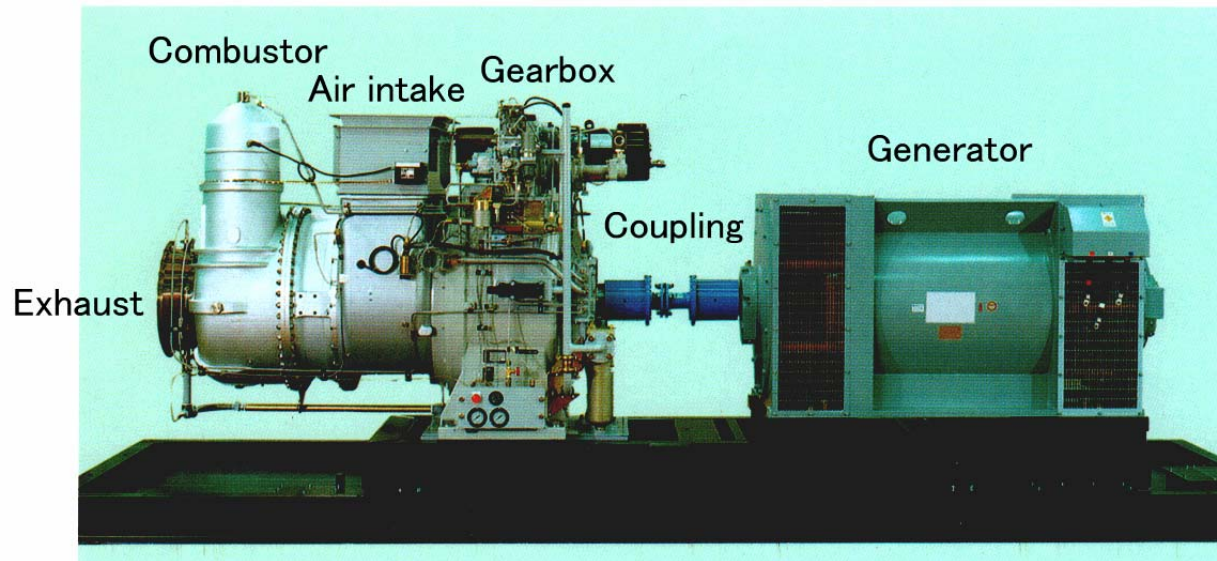
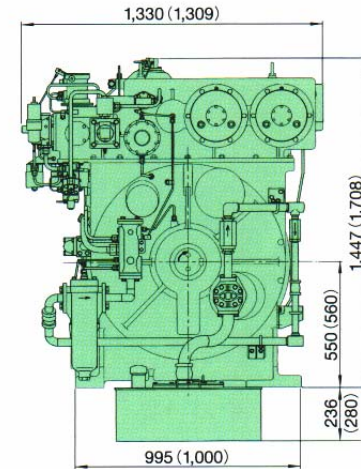
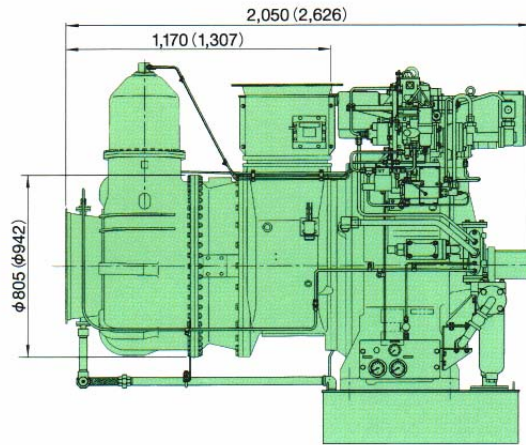
(M1A-01,-03,-06) : 3,020kg

(M1A-23) : 3,530kg

GPS4000 (M1T-23)

Engine weight: 7,700kg

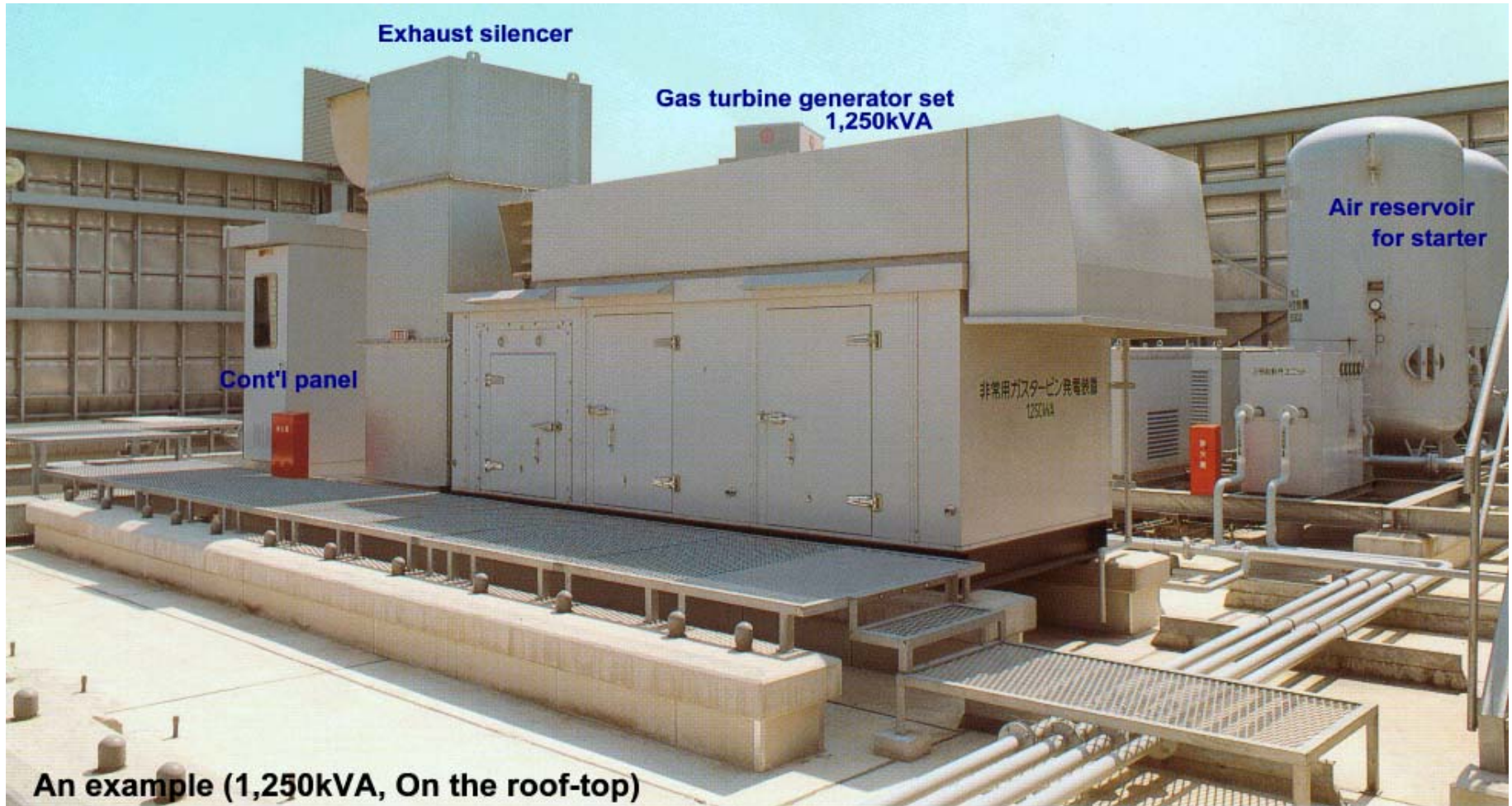
(P/S weight 2,680kg
incl'd)



An example of installation (500kVA)



An example of installation on the roof-top (1,250kVA)

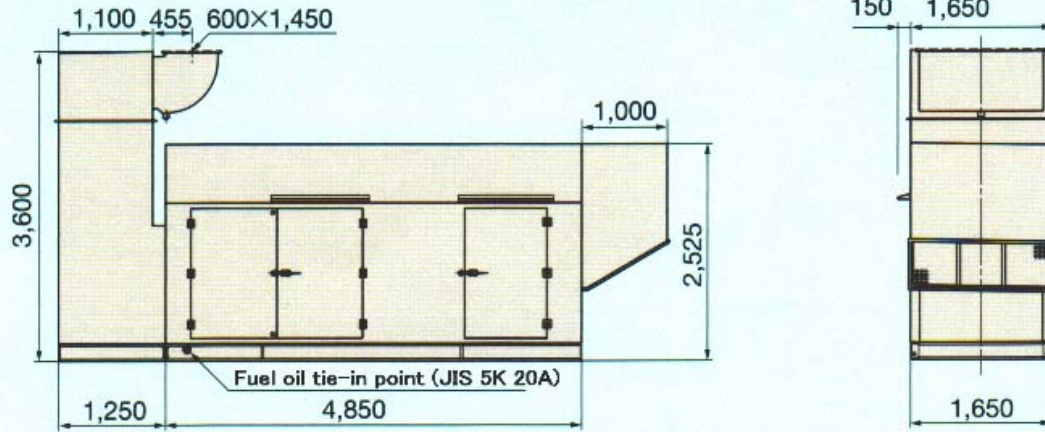


GTG Wt: approx. 12.5ton

Gas turbine generator set dimension

GPS1000/1250/1500/1750

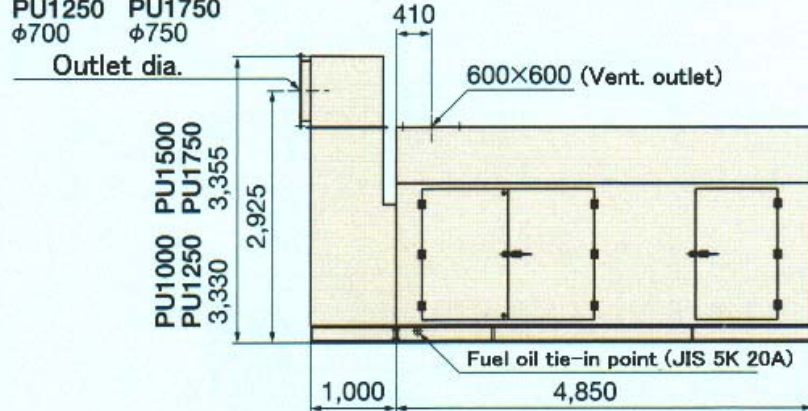
◆A-CR



Wt. : 13.45ton
(GPS1250)

◆B-ER

PU1000 PU1500
PU1250 PU1750
φ700 φ750

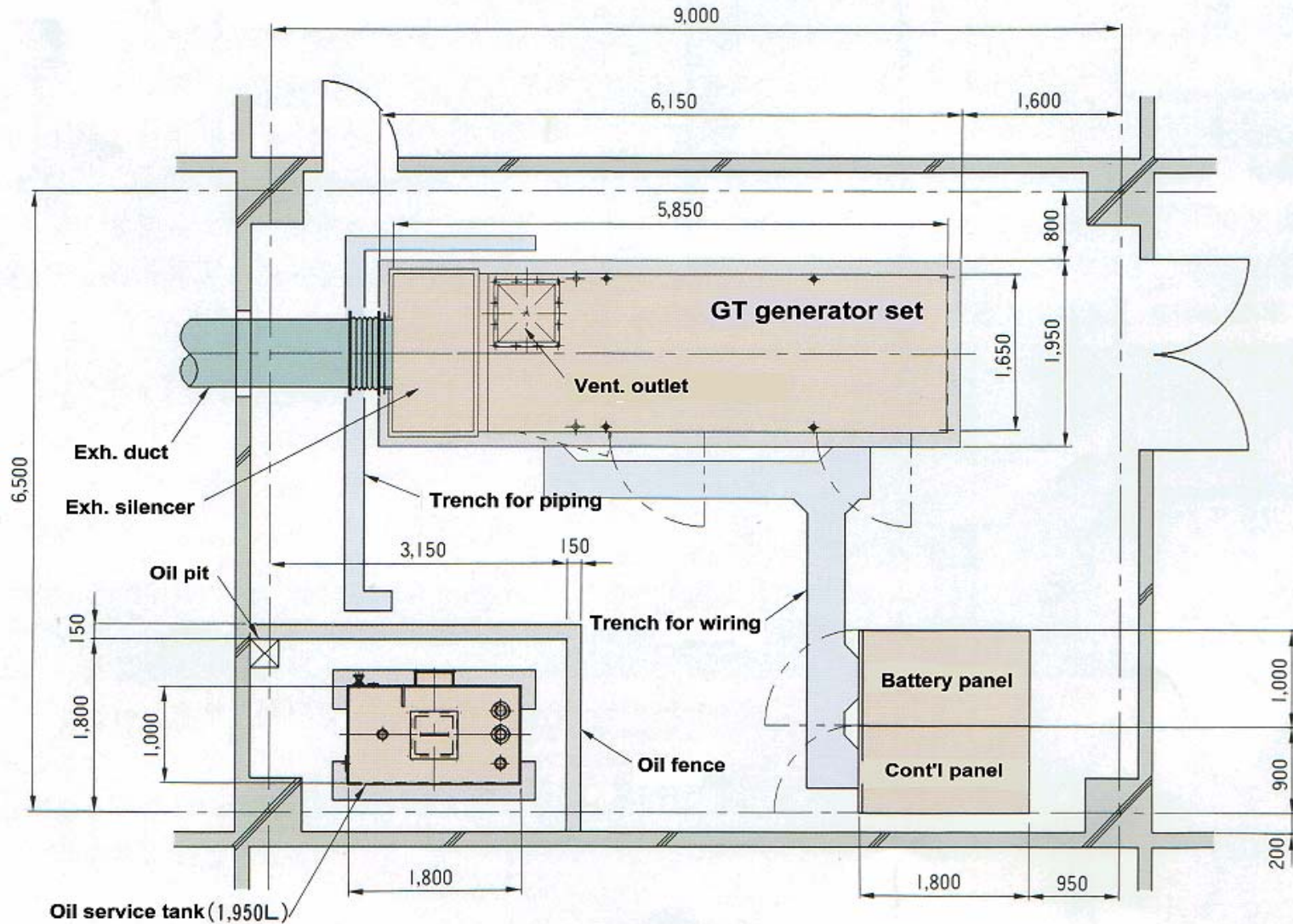


PU1000
PU1250
PU1500 PU1750
1,650 1,750



Wt. : 12.2 ton
(GPS1250)

Typical Plot plan of GPS1250 (just for reference)



Advantages of Gas turbine

1) **No cooling water**

- Free from water trouble(leakage, cooling, boiling, waste)
- No cooling system

2) **Low vibration**

- The static vibration of gas turbine is 1/4 of that of diesel engine
- The dynamic weight of gas turbine is 110% or less of GTG weight while it is about 50% for diesels.

3) **Low noise (85dBA)**

- Gas turbine produced noise is at high frequency, which is easy to attenuate.

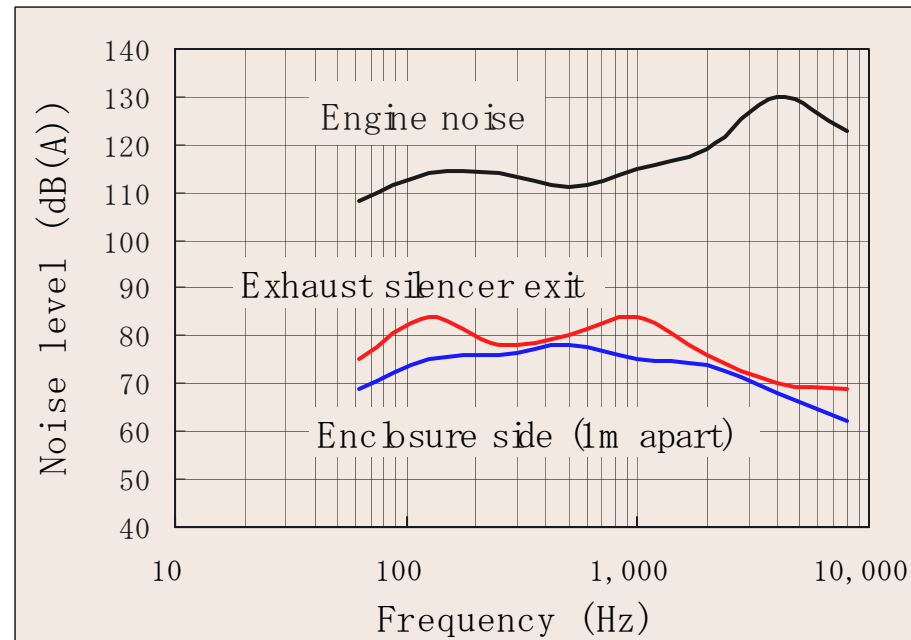
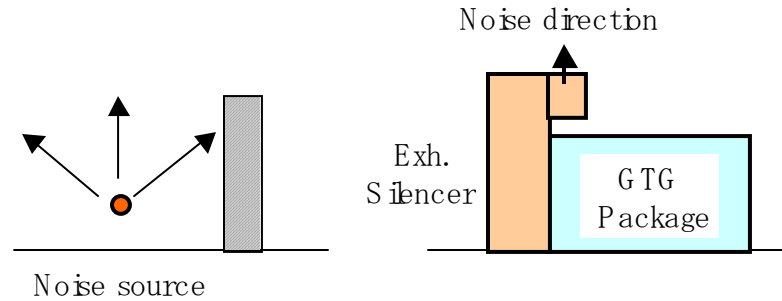
4) **Reliable starting**

High starting reliability is achieved by;

- forced ignition for Gas turbine (Diesel engine by natural ignition)
- low trouble ratio of Gas turbine due to simple structure and less auxiliary compared with diesel engine

Noise Reduction

- Noise reduction by the distance: $\Delta \text{dB} = (15 \sim 20) * \log_{10} L$, L: Length from a noise source
- Sound diffraction by a wall or a barrier
- Noise reduction by direction
- Noise reduction by acoustic absorption



Advantages of Gas turbine (Continued)

5) Compact and light weight

- Gas turbine: 1/4 in weight and 1/7 in volume of diesel engine

6) Excellent generating electricity

- due to rotating movement, high quality same as grid

7) Easy operation

- less auxiliary like pre lubricating, water cooling system

8) Clean exhaust gas

- Gas turbine: NO_x 120ppm, SO_x 100ppm, CO 15ppm, Carbon Nil
- Diesel engine: NO_x 700ppm, SO_x 150ppm, CO 500ppm, Carbon 500mg

9) Low installation cost

- Gas turbine: 1/4 in weight and 1/7 in volume of diesel engine

Advantages of Gas turbine (Continued)

10) Low maintenance cost/Low fuel and lube oil consumption

Inspection running

- Gas turbine: once per month (5min. per time)
- Diesel engine: once per two weeks (20min. per time)

11) Easy inspection

Maintenance interval

- Overhaul at 1000EOH (Equivalent Operation Hour)

*EOH: one starting is equivalent to one hour running

e.g. 20times starting/year + 10hours operation/year = 30EOH

1000EOH / 30EOH = more than 30years until overhaul

12) Quick loading time

- Starting time: within 40seconds at full load
- Instantaneous load: 100% (Diesel engine: 65-75%)

Advantages of Gas turbine (Continued)

13) Possible to start larger motor

- Due to reduction of high speed at 53,000-22,000rpm to 1,500rpm, Gas turbine create large inertia moment to absorb an inrush current at motor starting

14) Operates on a variety of fuels

- Available kerosene, diesel oil, high-grade heavy oil, natural gas, LPG, etc.
- Available dual fuel system (liquid fuel and gaseous fuel)

Comparison of Gas turbine and Diesel engine

Gas turbine - Diesel comparison (summary)

Condition:

Capacity	Approx. 4,000kVA
Fuel	Liquid fuel (Diesel oil)
Gas turbine	Single shaft industrial gas turbine
Diesel	Industrial general purpose diesel

Item	Type	Gas turbine	Diesel	GT	DE
Electricity generated	Transient speed fluctuation	±4% (100% load on) Recovery 2sec.	±10% (75% load on) Recovery 10sec.	○	
	Steady state speed fluctuation	±0.3%	±5%	○	
	Waveform distortion	3% or better	10%	○	
	Transient overload capability	Large due to large inertia moment	Small	○	
Prime mover	Principle of operation	Continuous combustion	Intermittent combustion		
		Rotating movement	Reciprocating move.		
	Dimension	Compact	Large	○	
	Weight	3 tons	9~10 tons	○	
	Cost	High	Low		○
	Starting time	Approx. 35-40sec.	Approx. 20sec.		○
Environment	Starting reliability	Over 99%	Around 95%	○	
	Noise level	85dB(A) at 1m	105~115dB(A)	○	
	Vibration level	10~15 μm	50~60 μm	○	
	Dynamic weight	Less than 1.1×static weight	More than 1.5×static weight	○	
Operation Cost	Emmission (Diesel oil)	NOx=85ppm (O ₂ :16%) SOx=100ppm CO =15ppm Carbon=negligible	NOx=700ppm (O ₂ :13%) SOx=100~150ppm CO =500ppm Carbon=500mg/m ³	○	
	Warming-up time	Not necessary	Required	○	
	Fuel consumption	1.5~1.8×Diesel	Less than GT		○
	Lube oil consumption	Less than Diesel	35~40×GT	○	
Construction Cost	Cooling water	Not necessary	4 tons/hr for cooling tower type 120 ton/hr for drain type		
	Genset price	High	Low		○
Construction Cost	Foundation, genset room, cooling water system etc.	Low	High	○	
	Fuel tank, Air system	High	Low		○

Comparison of Gas turbine and Diesel engine (Continued)

Condition:

Capacity	Approx. 4,000kVA
Fuel	Liquid fuel (Diesel oil)
Gas turbine	Single shaft industrial gas turbine
Diesel	Industrial general purpose diesel

Annual Operatin Hours for Maintenance

Maintenance item	Gas Turbine		Diesel	
	Once per 2-week for maintenance	Not required	0	20 minutes at no load
Once per 1-month for maintenance	5 minutes at no load	1hr	-	-
Every 6-month for functional maintenance	30 minutes at no load	30min.	30 minutes on rated load	30min.
Every 1-year for total maintenance	1 hour on rated load	1hr	1hr on rated load	1hr
Annual operatin hours	At no load	1hr 30min.	At no load on rated load	8hr 40min.
	On rated load	1hr	On rated load	1hr 30min.
	Total	2hr 30min	Total	10hr 10min.

Note: Maintenance schedule of Diesel is based on the maintenance recommendations by the Government.

Equivalent Operating Hours (E.O.H) for
Emergency & Stand-by use

$$TE = TR + S \text{ (hrs)} < 1,000$$

TE: E.O.H.

TR: Actual running hours

S: Number of starts

Comparison of Gas turbine and Diesel engine (Continued)

Annual Fuel Oil/Lube Oil/Cooling Water consumption for Maintenance

Maintenance item		Gas Turbine	Diesel
FUEL OIL	Fuel type	Diesel oil / Kerosene	Diesel oil
	Fuel consumption	① At no load 820 liter/h ② On rated load 1370 liter/h	① At no load 450 liter/h ② On rated load 930 liter/h
	Annual consumption	① $820 \text{ l/h} \times 1\text{hr } 30\text{m} = 230 \text{ liter}$	① $450 \text{ l/h} \times 8\text{hr } 40\text{m} = 3900 \text{ liter}$
		② $1370 \text{ l/h} \times 1\text{hr} = 1370 \text{ liter}$	② $930 \text{ l/h} \times 1\text{hr } 30\text{m} = 1395 \text{ liter}$
		Total 2600 liter	Total 5295 liter
LUBE OIL	Lube oil type	Synthetic	Mineral
	Lube oil consumption	0.08 liter/hr	Approx. 6.5
	Annual consumption	$0.08 \text{ l/h} \times 2\text{hrs } 30\text{m} = 0.2 \text{ liter}$	$6.5 \text{ l/h} \times 10\text{hrs } 10\text{m} = 66 \text{ liter}$
Cooling water	Not required	120 tons/hr for drain type	
		4 tons/hr for cooling tower type	

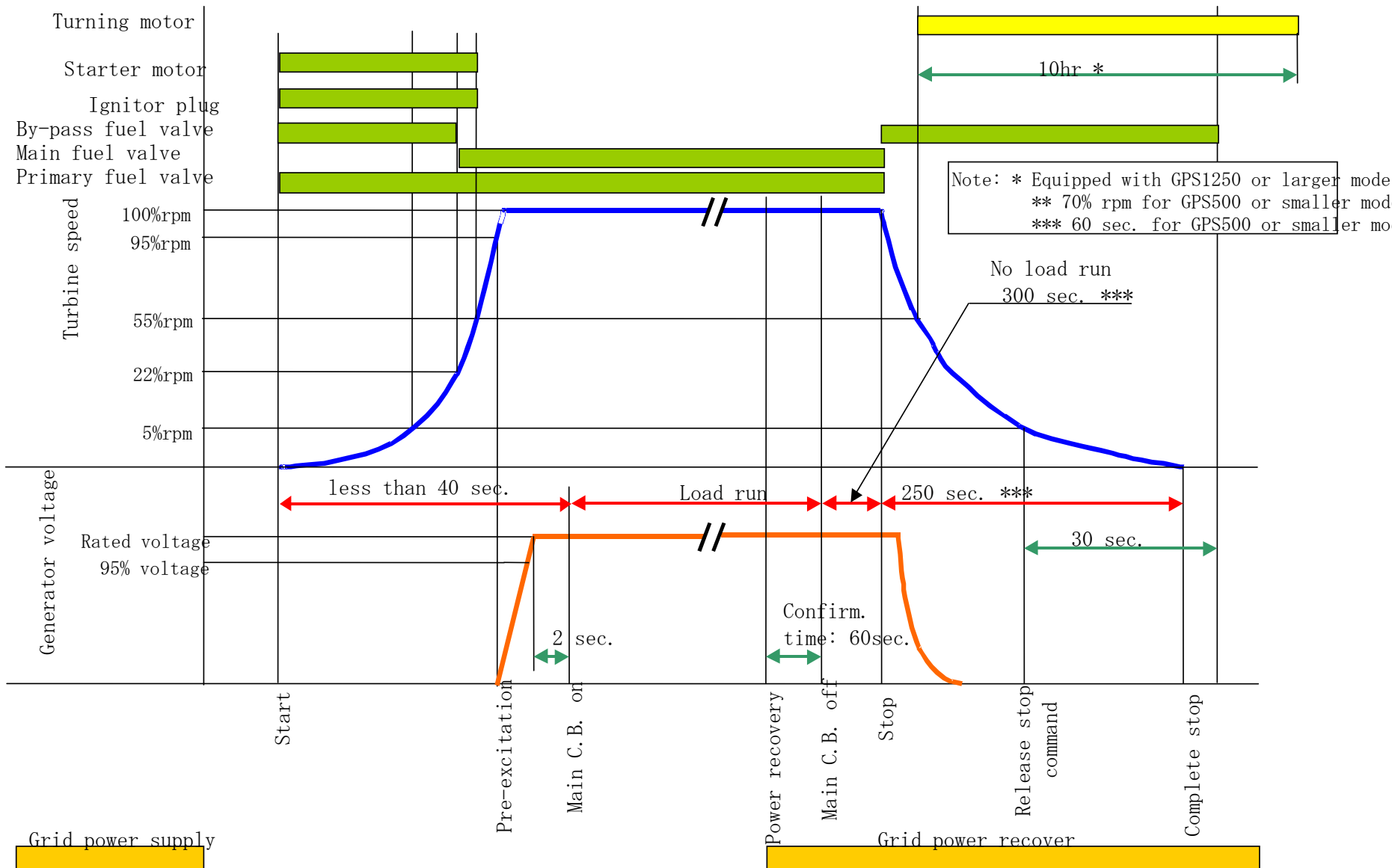
- Lube oil consumption of Gas turbine

0.05 ltr/hr - 0.16 ltr/hr (Kawasaki GP series GT)

Oil type: Synthetic oil (ASTO500, ASTO750, Mobile JET II,

Castrol 5000, Exxon ETO2380 etc.)

Typical timing chart of operation (Stand-by, Liquid fuel)



Voltage wave form

1500 KVA Generator

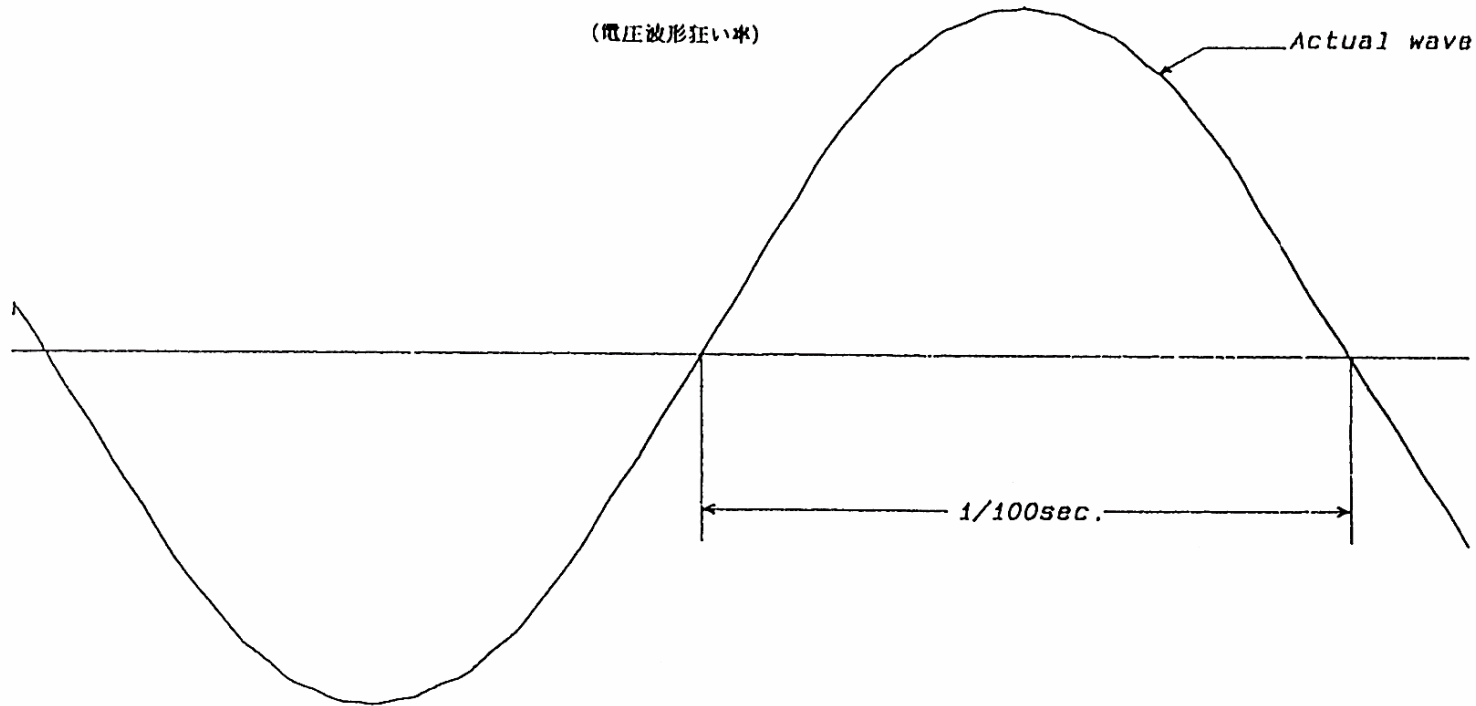
Machine no.:EBA094H0101

Voltage Wave Form.at Rated Voltage 6600 V

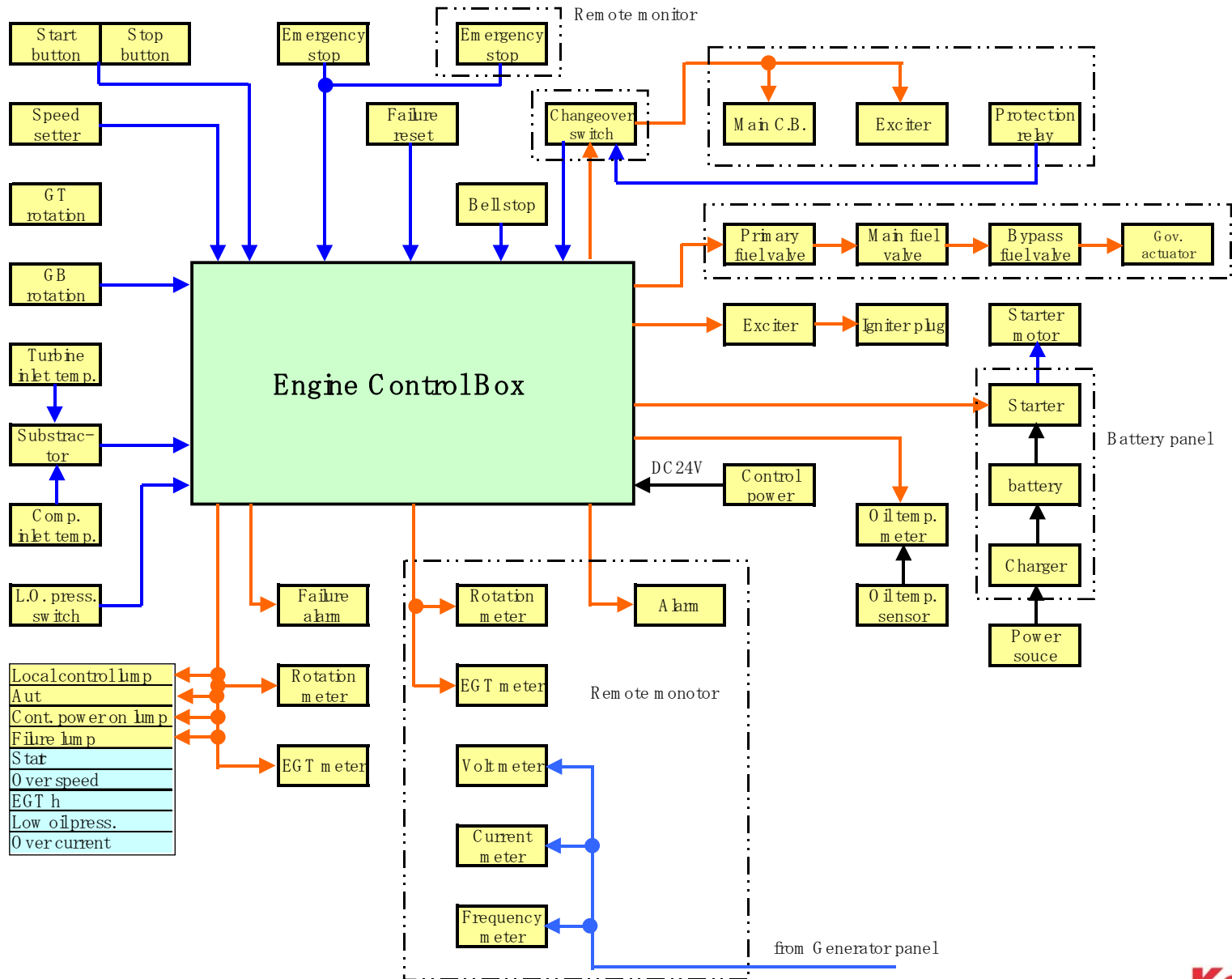
Date : 09/09/97

Deviation Factor = 1.71 %

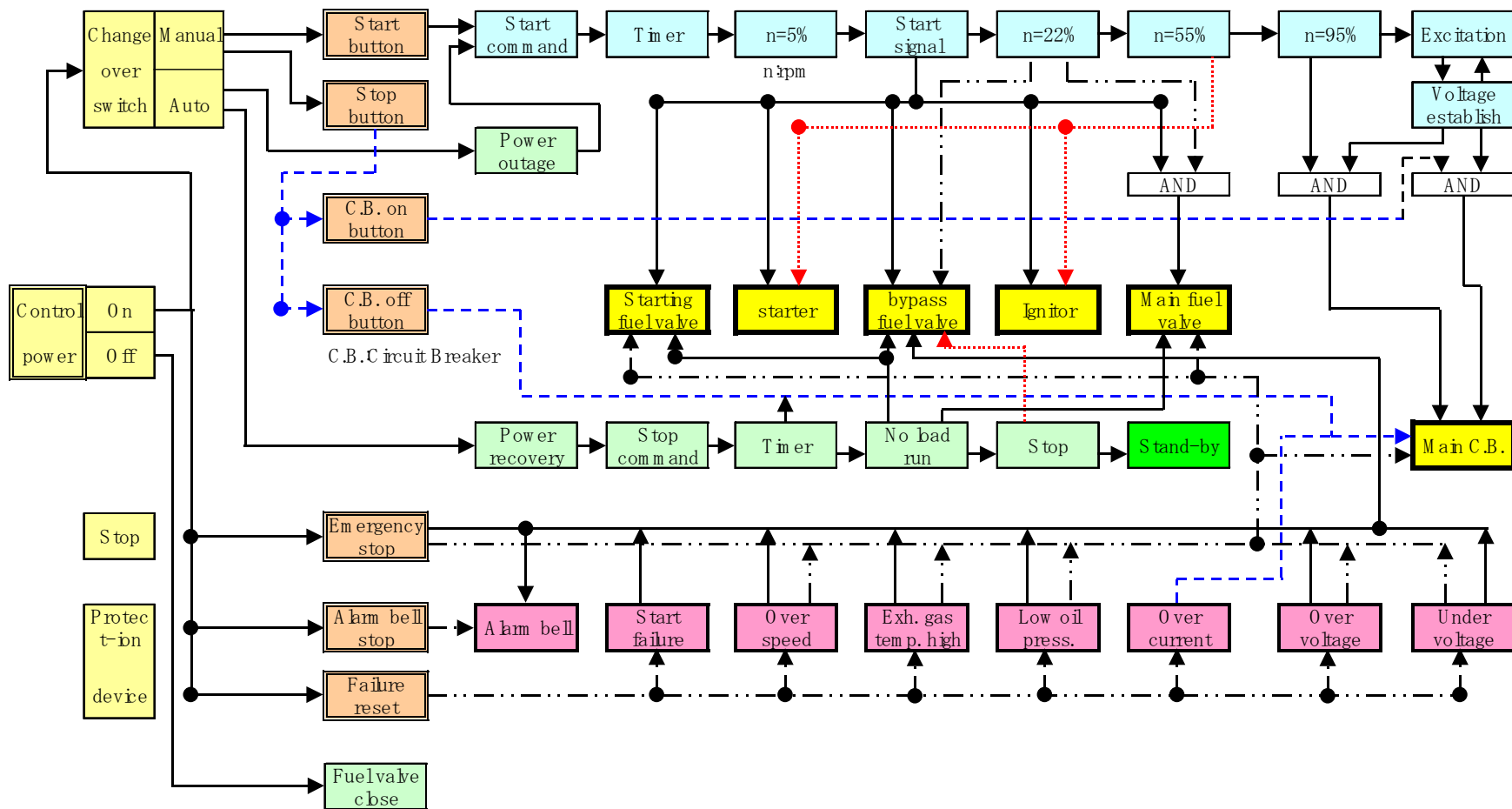
(電圧波形歪み率)



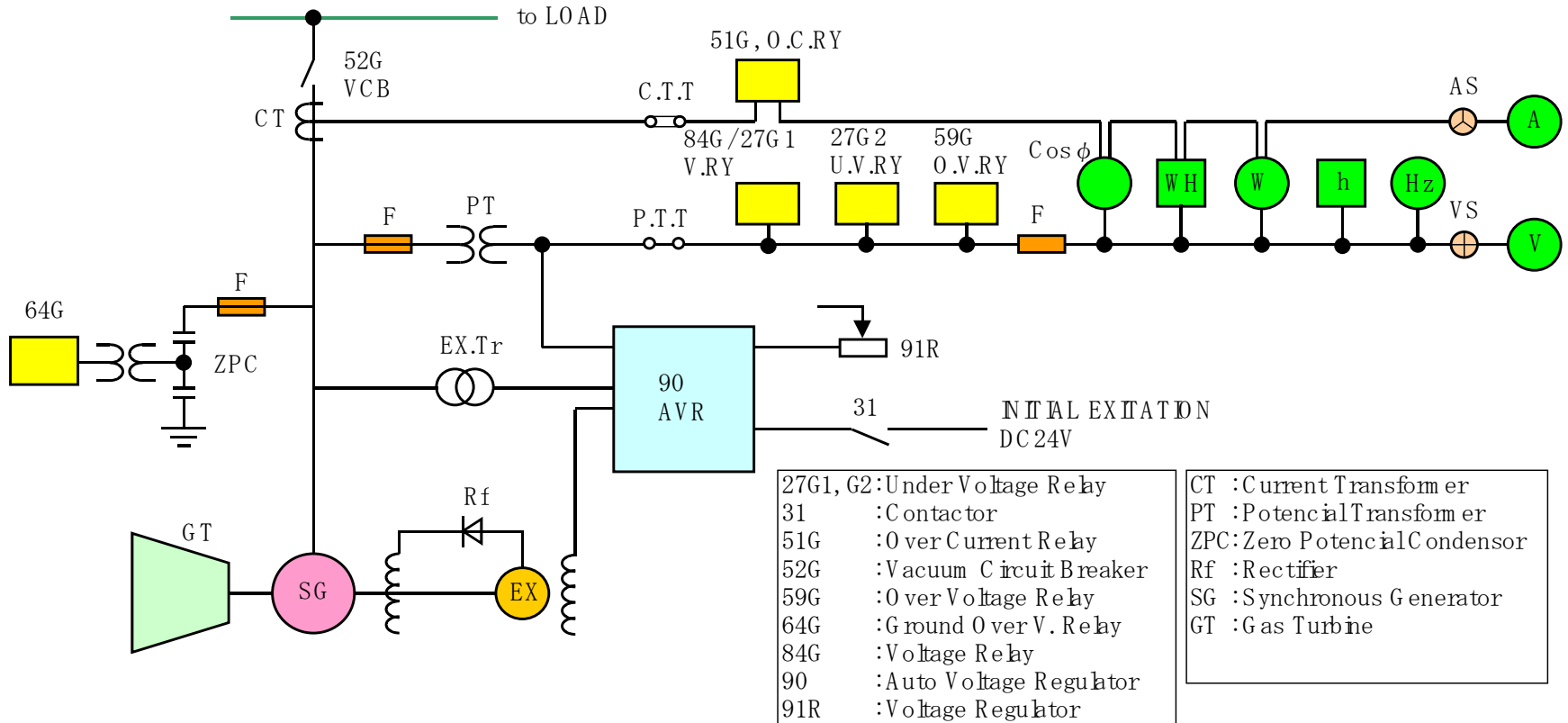
Typical control system block diagram



Start / Stop sequence diagram



Single line diagram (typical)



Typical protection system

		GPS250	GPS500	GPS625 ~ GPS4500
Trip	Over speed	○	○	○
	EGT high HH	○	○	○
	Lube oil press. low	○	○	○
	Lube oil temp. high	—	○	○
	Start failure	○	○	○
	Emergency stop	○	○	○
	Over voltage	○	○	○
	Under voltage	○	○	○
	Alarm	Over current	○	○
Low engine speed		○	○	○
Reverse power		○	○	○
EGT high H		○	○	○
Sensor failure		○	○	○
Ground fault		○	○	○
Battery liq. level low		○	○	○
Fuel tank level high		△	△	△
Fuel tank level low		○	○	○
Aux. device failure		○	○	○
Fail to synchronize		○	○	○

△ : option

EGT: Exhaust gas temp.

END OF PRESENTATION