Tab A.2.1

Operating Philosophy

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A.2.1.1. General

A.2.1.1.1. Plant Configuration

The plant consists of four conventional oil fired thermal generating units which has electrical plant output of about 660 MW. Major systems/components of the plant are;

- Steam Turbine and Condensing system
- Boiler and Ancillary Plant
- Selective Catalytic Reduction Plant
- Electrostatic Precipitator
- Flue Gas De-Sulfurization Plant
- Feed Water heating System
- Boiler Feed Water Pumps
- Auxiliary Steam System
- Circulating Water System
- Seawater Intake System
- Electrochlorination System
- Plant Closed Circuit Cooling Water System
- Fuel Oil System
- Compressed Air System
- Seawater Desalination Plant (RO)
- Demineralized Water system
- Condensate Polishing System
- Demineralized Make-up Water System
- Potable and Domestic Water System
- Service Water system
- Waste Water Treatment System
- Steam and Water Sampling System
- Chemical Dosing System

- Hydrogen Generation Plant
- Etc.

Specific description and technical data for each system/component can be seen from system description and equipment sizing report for the individual system.

A.2.1.1.2. Site Condition

The plant will be operated safely and reliably over the full range of site ambient conditions listed below;

Item No	Description		Particulars
1.	**SITE AMBIENT DATA**		
1.1	Site location		Shuqaiq – approximately 135 km North of Jazan , 105 Km South of Abha and 580 South of Jeddah on 6 km off Main Jeddah –Jazan road on the Red Sea coast
1.2	Site elevation (above sea level)	m	4 (not less than)
	Design ambient conditions (Site rating):		
1.3	Design ambient pressure	mbar	1013
1.4	Design ambient temperature (dry bulb)		50°C
1.5	Design relative humidity	%	30
	Ambient temperature (dry bulb):		
1.6	Highest maximum (recorded)	°C	50
1.7	Maximum yearly average	°C	35
1.8	Maximum daily average	°C	35
1.9	Design maximum temperature (in the shade)	°C	50

Item No	Description		Particulars
1.10	Design temperature of electrical installed equipment installation °C air condition of rooms with HVAC n-1 redundancy		40
1.11	Max. metal temperature under the sun	°C	85
1.12	Lowest minimum (recorded)	°C	3
1.13	Design minimum temperature	°C	5
	Relative humidity:		
1.14	Maximum (recorded at 40°C)	%	100
1.15	Minimum	%	5
1.16	Yearly average	%	70
	Precipitation:		
1.17	Mean annual rainfall	mm	102 mm
1.18	Max 24 hour rainfall	mm	111 mm
	Wind speed:		
1.19	Prevailing direction		North Westerly
1.20	Average wind speed	m/s	3.7
1.21	Max 10 yr wind speed	m/s	24.7
1.22	Max recorded wind speed	m/s	40
	Air quality:		
1.23	Air pollution		*Please read note below
	Seismic:		
1.24	Seismic Zone Classification		UBC Zone 2A

*Note:

Pollution

The region of installation is subject to sand and dust storms, salt laden winds, corrosive sulphurous atmosphere and fog. Usual dust in air concentration is as high as 1 mg/m^3. During sandstorms concentrations of 100 – 500 times higher may be encountered. 95 per cent of all particles are below 20 micrometer and 50 per cent of all particles are below 1.5 micrometer in size. It consists of calcium, silicon, manganese, aluminium and sodium compounds and in the presence of high humidity it can conduct electricity and corrode metal. All enclosures shall be designed and adequately protected to prevent ingress of dust.

This Schedule shall be read in conjunction with Clause 2.4 of Volume 1, of the Technical Specification.

A.2.1.2. Operating Philosophy

The plant will be designed to withstand the prevailing ambient conditions to which it may be exposed and to continue to function normally. The plant will be designed to operate continuously throughout the year and will be designed to have an expected operational life of 30 years.

The Stage-I plant will be designed for base load operation, although the plant will also be capable of daily start-up and shut downs. The plant will be designed for a minimum number of starts in unit life time, as follows:

a. 200 cold starts

b. 1170 warm starts

c. 4680 hot starts

The turbine generator plant and its associated boiler plant will be designed to be capable of the following load changes and ramp rates:

Load change	ramp rate
20% - 35%	1.5% per min
35% - 50%	3% per min
51% - 100%	4% per min

The steam turbine generator set will be suitable for parallel operation, in island mode as well as on an interconnected grid and will be capable of supplying maximum available power without any malfunction or failure within the parameters as required by Specification and the Saudi Arabian Grid Code.

A full load rejection to plant auxiliary power demand will not cause the turbine generator to trip, but will trip only the associated HV breaker, keeping the T/G unit in islanded operation to maintain power supply to unit and station auxiliary services as appropriate.

The turbine generator set will be suitable for parallel operation, in island mode as well as on an interconnected grid and will be capable of supplying maximum available power without any malfunction or failure within the frequency variation as per Grid Code.

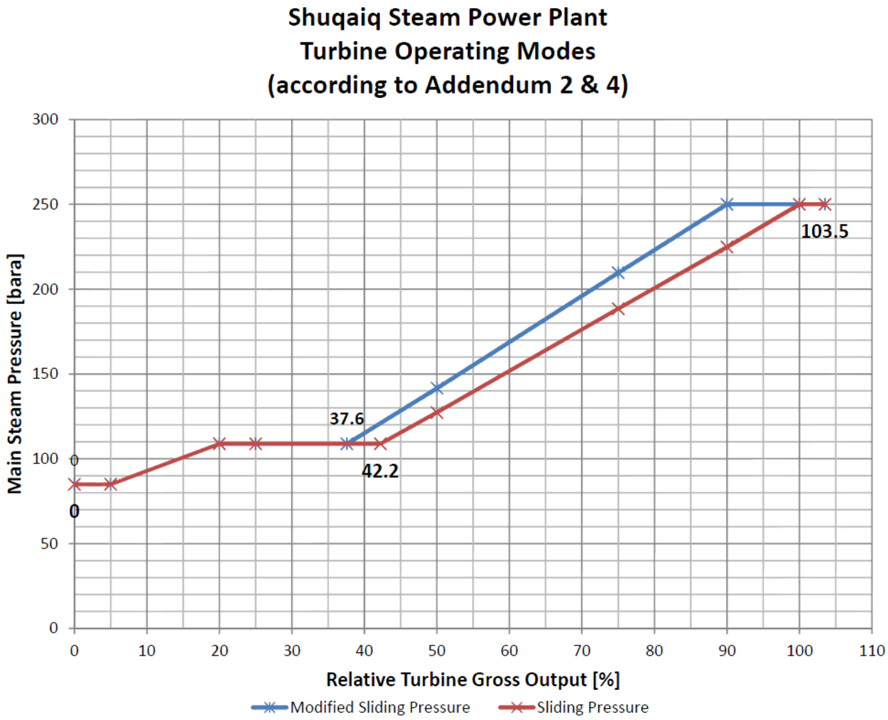
Below Nominal Frequency (Hz)	Above Nominal Frequency (Hz)	Operation Requirement
58.8 – 60.0	60.0 – 60.5	Continuous
57.5 – 58.7	60.6 – 61.5	for a period of 30 minutes
57.0 – 57.4	61.6 – 62.5	for a period of 30 seconds

A.2.1.3. Plant Operation Mode

A.2.1.3.1. Sliding and Modified Sliding Pressure Mode

The units will be designed for operation in both modified sliding pressure mode and sliding pressure mode as indicated in the heat balance diagrams. The overload valve will allow the turbine to accommodate additional steam flow up to the BMCR condition, at constant pressure.

The more detailed figure about the modified sliding pressure mode and sliding pressure mode is given as below;



TMCR = Main steam control valve full open at 250 bara

VWO (BMCR) = Main steam control valve full open & overload control valve open at 250 bara

After start-up and synchronization, the steam turbine will be automatically loaded by means of load program. During this phase the HP bypass valve is used to control the main steam pressure. After closing the HP bypass valve the Initial Pressure Controller (IPC) is automatically switched on and controls the main steam pressure.

With increasing boiler load and steam flow the Main Control Valves (MCVs) will be opened via IPC according to the main steam set-point derived from the unit controller. In this operation mode the MCVs are fully open, the control shifts automatically from IPC to valve position controller. In this operation mode the MCVs are fully open and the Overload Valves (OLVs) are closed.

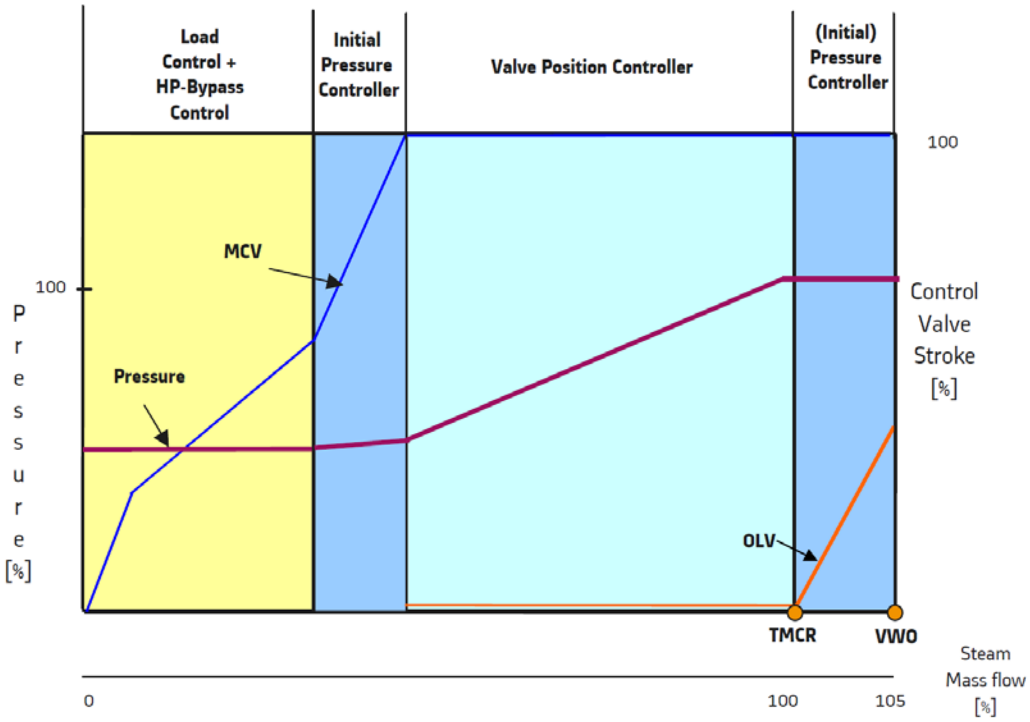
With increasing boiler load the pressure increases up to nominal pressure while the steam turbine is in sliding pressure operation mode.

For the OLV operation two scenarios are possible;

a) When OVL operation is required due to frequency support the main steam flow through the ST is increased by opening the OLVs.

b) For a scheduled load increase the valve control mode is switched to IPC if pressure exceeds nominal pressure (TMCR). To maintain main steam pressure the IPC opens the OVLs until VWO is reached.

To end OLV operation the steam flow has to be decreased by reducing boiler output. This closes the OLVs by means of the IPC until the nominal pressure is reached again. At this stage the control mode switches back to the Valve Position Controller.



Main Steam Pressure & Valve Stroke versus Steam Mass Flow

A.2.1.3.2. MW Demand Control

A common MW demand for the power station has to ensure that all units contribute meeting this demand within each of the unit capacities and limitations

Therefore the common or total demand for the power station is split into 4 individual demands, one for each unit. Because the units have identical capacity each unit received one quarter or 25% of the total demand. A factor 0.25 using a multiplication function in each unit demand ensures equal distribution. If at a later stage one of the units has a different capacity then this can be adjusted using these multiplication functions.

The common set-point is used from a single control center allowing that all or some unit demands can be controlled from one control station. To enable this operation at least one unit has to be selected to remote demand control in its unit control system. If all units are selected then the power station output can be controlled from one single set-point station.

This MW demand control system allows that each unit can be biased as required, it ensures control of all remaining units if one unit is on manual, shutdown, has a run back condition or is at its minimum or maximum limit.

A.2.1.3.3. Unit Operation Mode

The Unit Coordinate Control (UCC) is designed to create the following proper demands for the boiler and the turbine depending on the unit operating conditions.

- Boiler Input Demand
- Turbine Master Demand
- Boiler Input Rate Demand

The relationship between these demands depends entirely on the mode of operation chosen. The Unit Coordinate Control is capable of being operated in the following modes.

- Coordinate Control Mode (CC)
- Boiler Follow Control Mode (BF)
- Boiler Input Control Mode (BI): including Turbine Follow Mode
- Boiler Manual Mode (BM) : including Turbine Follow Mode

1) Coordinate Control(CC) Mode

This is the normal operation mode of the unit. The Unit Load Demand (which is MW demand) is given to both the boiler and the turbine so that energy input into the boiler matches to the energy output from the turbine. Turbine governor control will follow the MW demand directly. Boiler input control will follow MW demand which is corrected by main steam pressure deviation. Stable operation could be expected in this mode of operation since turbine governor valve respond to MW demand quickly and boiler load will also be quickly changed. This control mode could also be most contributed to the network requirement.

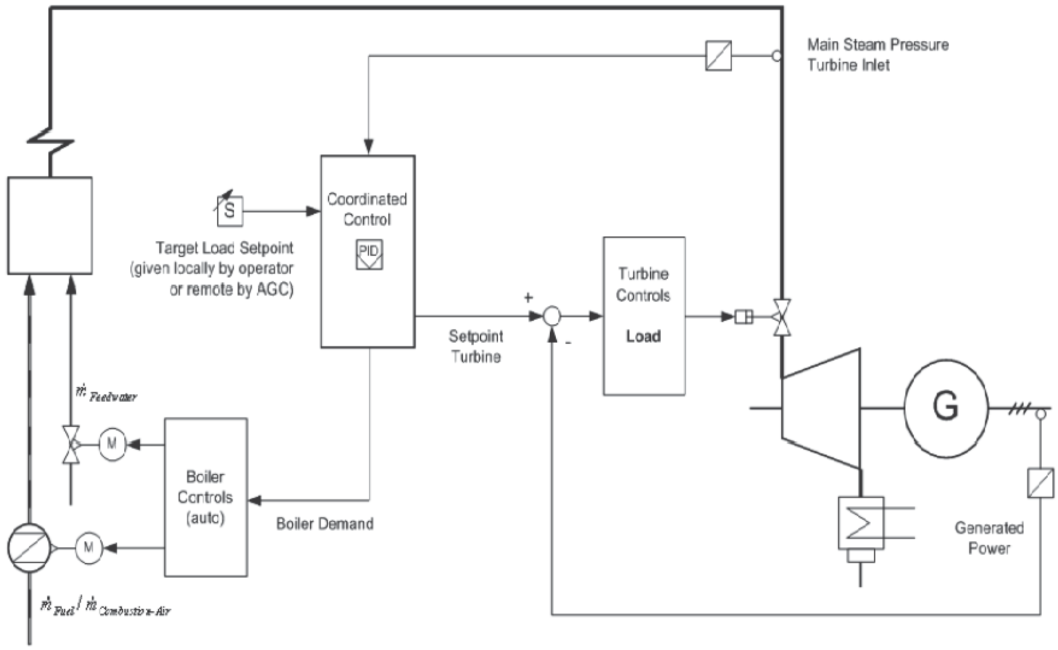
In the case of once-through boilers, the MW, main steam pressure, main steam temperature, excess O2, and reheat steam temperature which are the main control parameters in Closed Control System are all affected in some way or another if any one of the main steam flow, feed water flow rate, air flow rate and superheater spray flow rate which are the main objectives of manipulation is changed. Therefore, it is necessary to control all the objectives of manipulation in parallel and minimize mutual interface thereby achieving coordinated control.

In order to put into the CC mode operation, not only the boiler input control and the turbine master control but also all major control loops of the boiler such as feed water, fuel flow, air flow and furnace pressure control are to be kept in automatic mode.

The other control modes described below use a different control strategy because MW demand sent from Load Dispatch Center and/or set by operator manipulation is not applicable. Instead of a coordinated turbine and boiler demand signal, main steam pressure is controlled with one of the control loop in automatic mode while the other is operated in manual mode.

While operating in Coordinated Control Mode, the control system keeps a proper relationship of steam generator and steam turbine operation. Boiler and turbine respond to the control in parallel and accordingly. Main steam pressure is controlled by the boiler while the MW is controlled by the turbine.

And the initial pressure controller and valve position controller as superimposed controller is in the automatic controller of the turbine control system. Theses controllers ensures that the unit can be operated with fixed and sliding pressure range.

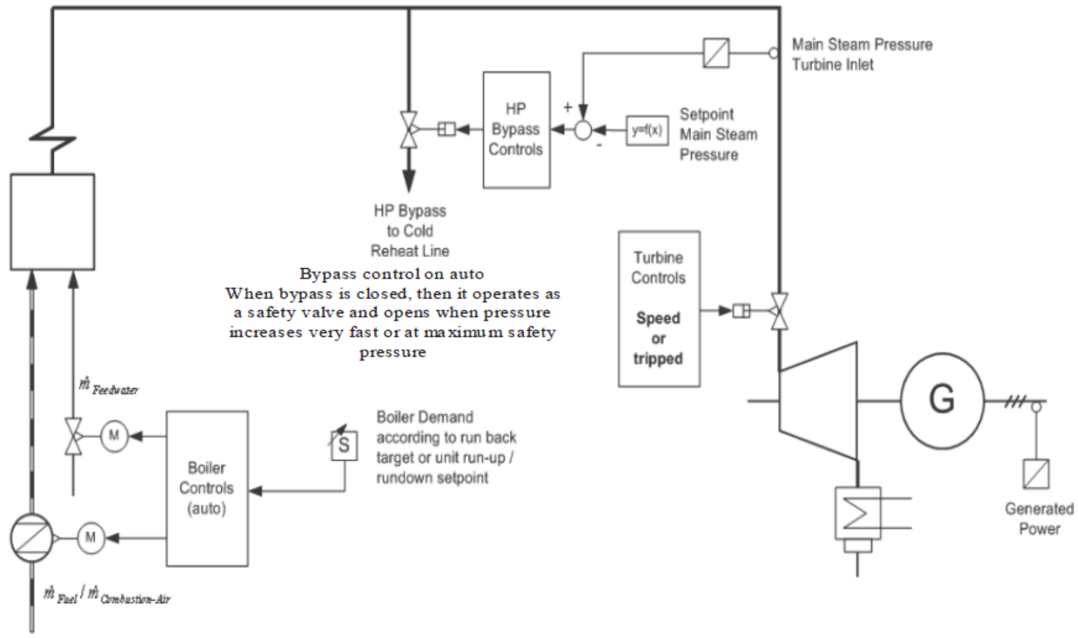


Schematic Diagram of Coordinated Control (CC) Mode

2) Boiler Follow Control(BF) Mode

When the turbine master is changed to Manual mode during CC mode operation, operation mode is shifted from CC mode to BF mode. In this mode of operation, unit loading is changed by operator manipulation via the Turbine master control in manual. Under the condition of “Boiler Input Control Auto” and “Turbine Master Manual”, the demand to the boiler is automatically set to control main steam pressure which is corrected on actual MW signal.

MW demand signal is tracked with actual MW in this mode.



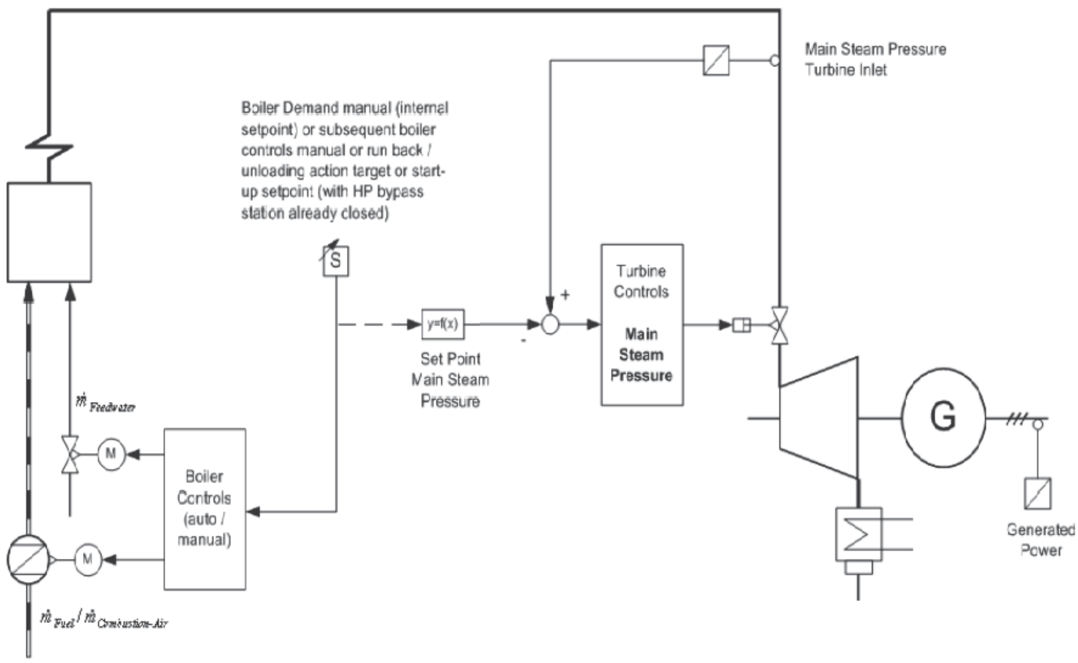
Schematic Diagram of Boiler Follow Control (BF) Mode

3) Boiler Input Control(BI) Mode

In this mode of operation, boiler input is given by operator manipulation. This means that unit loading is changed by operator via the Boiler Input Control. Under the condition of “Boiler Input Control Manual” and “Turbine Master Auto”, the demand to the turbine governor is automatically set to control main steam pressure. Most stable unit operation could be expected in this mode since boiler input is directly adjusted. However, response to the unit load requirement will be inferior to CC and BF modes.

MW demand signal is tracked with actual MW in this mode.

When runback occurs, Boiler Input Control Mode is automatically selected.



Schematic Diagram of Boiler Input Control (BI) Mode

4) Boiler Manual(BM) Mode

This mode will be used during unit start-up and shutdown period. When the feed water control is changed to manual mode during dry mode operation, or fuel flow control is changed to manual mode during wet mode operation, this mode is selected automatically. In this mode of operation, there is no control on the unit load.

If the Turbine master is in automatic mode, turbine governor will control main steam pressure.

A.2.1.3.4. Wet/Dry Transfer

Forced circulation operation mode by Boiler Circulating Pump running is so called "Wet operation" and once through operation mode is so called "Dry operation". Wet operation can be considered as drum type boiler.

Dry operation can be applied when steam generation exceeds minimum main feed water flow. Main feed water flow is proportionally increased to steam generation with load increase and also WSDH level is gradually decreased. Boiler recirculation flow is gradually reduced and BCP minimum flow valve is opened, when boiler recirculation water flow falls below preset value.

When the permission is established, BCP is stopped and operation mode is transferred from wet to dry. The boundary of operation mode which is called “Run out point” is inarticulate and unstable because of its dependence on WSDH level and superheat ratio at WS inlet.

In case of load down, WSDH level is gradually increased around the run out point. When the permission is established, BCP is started and operation mode is transferred from dry to wet.

A.2.1.3.5. Fuel Supply Control

Fuel flow demand will be calculated based on the Boiler Input Demand. Water/fuel ratio demand with cross-limited function will be considered for determining the total fuel demand. Calculated fuel flow demand will be transferred to the Burner Management System (BMS).

The BMS is designed to ensure the execution of safe orderly operating sequence in the start-up and shutdown of fuel firing equipment. The system will provide monitoring, control & protection of fuel firing equipment and associated combustion air systems. It will facilitate highly reliable and effective boiler operation with close coordination with other plant control systems such as APS and APC. Related conditions from other control systems are monitored and used for control to achieve highly reliable and effective boiler operation.

There are two (2) operation modes in burner system, i.e. local operation mode and remote (manual/automatic) operation mode.

In the local operation mode, oil burners are manually operated individually from the oil burner local operation panel located at the burner area. This mode is used when testing and burner maintenance, but not during normal boiler operation.

In remote operation, the oil burners and igniters are started and shutdown manually by the operator intervention or automatically by the BMS load program and/or by the upper level APS.

The load program is initiated automatically by APS command signal to BMS or by manual initiation from CCR when more than two (2) HFO burner elevations are in service. In load program operation, the burners are started and shutdown automatically according to the boiler load.

The plant start-up and shutdown operation is controlled from the APS. The initial burners during start-up and the final burners during shutdown operation are initiated by the APS and coordinates related BMS conditions with the other plant control systems.