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# A LESSON LEARNED
# INITIAL SERVICE TESTING FOR 2 PHASE LINE AND STEAM LINE OF 110 MW WAYANG WINDU UNIT 2 FIELD

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## ABSTRACT

In Geothermal steamfield above ground systems, 2 phase pipe line usually used very large diameter (greater than 1 meter) covering long distances and varying elevations over cross country. Hydrostatic testing of these systems is becoming problematic and usually not so practical, this is because the piping is typically not designed for full water load, the large volumes of water required, and often the changes in elevation make it impossible to test the whole system at once.

Initial service test is therefore preferred internationally as it often significant advantages over hydrostatic testing and is proposed for testing of the Wayang Windu unit 2 Steam field Above Ground System large diameter (36", 42" and 48") two phase and steam piping. So this is a lesson learned from Wayang Windu unit 2 whereas the initial service test has been done and performed at "normal operating pressured". For the first time, this testing has been approved and the field had received the SKPP and SKPI form EBTKE (former DJMBP). This techniques has reduced the EPC completion time and reduce the cost in term of civil work.

In-service test is actually quite simple and the procedure followed ASME B31.1 Power Piping. in principle, the line is headed to 100 deg C with all vents and drains are opened ie under no pressure and then after temperature raised and the pressure raised to the service test pressure. This test to be a more stringent test as the thermal loading is likely exceed loading under a hydro-test at ambient temperature. Service leak test are common practice for Geothermal Project worldwide, Mighty Power River from New Zealand and also in Kenya and Philippines and Nicaragua they have been using service leak tests on their new geothermal pipelines as their standard for some time. This best practice could be proposed to EBTKE, as regulator, to adopt it into their regulation regarding safety audit to installation, equipment and technique use in geothermal activities.

## INTRODUCTION

Steamfield of Above ground system (SAGS) including the wellpad equipment, pipelines, separator station and the scruber station for Wayang Windu Unit 2 has to be designed to provide steam for Power Generatng 117 MW of the Wayang Windu geothermal power project. Geothermal steam and fluid from production well is piped the separator station. There are 3 cylone separators are used to seperate the steam from the two-phase liquid from the production wells. 2 scrubbers of corrugate type are provided just before the power station to eliminate further moisture. Surplus steam will be released to the atmosphere through vent valves.
2 rock mufflers are provided to reduce the noise level if the steam released.

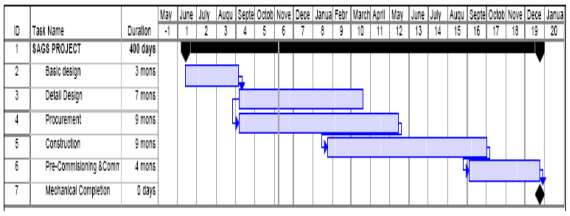
*Figure 1: SAGS of Wayang Windu geothermal field*

***SAGS design***
Largest Pipe Diameter : 48”
Other Pipe diameter in cross country lines: 36”, 42”
Estimate Total Pipe Length : 4000 m

Estimate Total Volume : 4600 $m^3$
Operating Pressure : 10.8 bar g (at separator)
: 14 bar g (at well branch pipe)
The 36" two phase pipe line can be shown at fig.1.

***SAGS scope statement***
SAGS scope statement is to design, procure and construct SAGS as per contract requirements in order to meet turbine inlet design point condition with delivering steam as required with steam flow 222.5 kg/sc Pressure 11.2 bara at saturated temperature, Steam quality 99.95% dryness at PS-SAGS interface point.

***SAGS schedule***
The EPC of SAGS of the Wayang Windu geothermal power project should be fineshed in 18 months readiness to deliver steam for commissioning of power plant. The critical path of the project is run through the engineering, procurement of material, installation and commissioning. This tight schedule
*Table 1: SAGS Schedule*




should be reached with fullfill the owner project specification and requirement.

The pre-commissioning and commissioning of SAGS which are in the critical path to be well prepared due to considering the nature of SAGS pipe line covering long distances and varying elevations over cross country. Hydrostatic testing of these systems is becoming problematic and usually not so practical, this is because the piping is typically not designed for full water load, the large volumes of water required, and often the changes in elevation make it impossible to test the whole system at once.

## PROPOSED PRESSURE TESTS

SAGS piping could be interpreted as "non-boiler external ASME B.31.1 as shown the illustatrion at fig.2 and acording to the ASME B31.1 POWER Piping Presure Test the Non Boiler External Piping shall be tested by the following method:
- Hydrostatic test (Clause 137.4)
- Alternative Leak Test:
  - Pneumatic Testing (Clause 137.5)
  - Mass Spectrometer and Halide Testing (Clause137.6)
  - Initial Service Testing (Clause 137.7)

The poposed test plan is decided that hydrostatic Test will be carried out to all well branch lines which is generally has higher pressure. Pneumatic Test will be carried out for Compressed isntrument air lines. Meanwhile Initial Service Test (IST) has to be done for Large diameter long cross country pipes

## WHY INITIAL SERVICE TEST?

The decison to use the initial service test for the two phase line and steam line was made in order to mitigate the risk of schedule during the precommissioning stage. The basic reason we prefer the initial service test instead of other test for the 36" and 48" two-phase and 42" main steam pipelines are as follows:
- The Piping is not designed for full water loads;
- The elevation changes in the piping maske it impossible to test the whole system at once;
- SAGS will need source of water and a large of water volume and very long piping in undulating and often difficult to find from the country side;
- The huge amount of water used will interrupt village supply;
- The disposal of Water will have some environmental impacts on fish farms, tea and other horticulture plantations;
- SAGS pipe line layout has extreme elevation change will have such as variation of hydrostatic head in pipeline
- Pneumatic testing is notpractical because the large volumewill make detection of pressure charges and therfore leaks, very dificult;

SAGS cross country piping satisfies the definition of "Non Boiler External Piping" and conditions as described in ASME B31.1 clause 137.3.2 Nonboiler External Piping and ASME B31.1 clause 137.3.3 rrequirement for spesific piping system of Power Piping Pressure Test of Non Boiler External Piping. Two conditions apply here are
- Has to be specified by Owner
- Has to be non-boiler external piping


*Figure 2: Illustration of ASME B 31.1 definition of "Nonboiler external piping"*

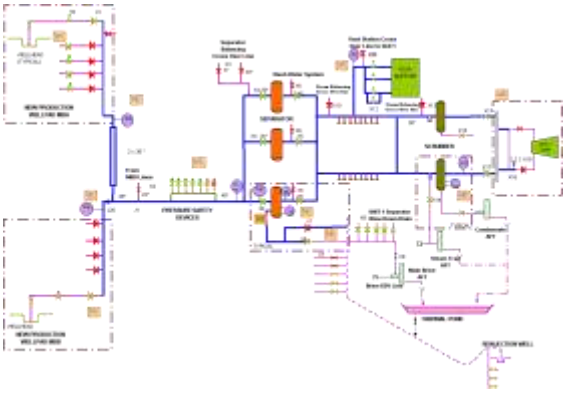


*Figure 3: Illustration of* ***Wayang Windu Unit 2 Initial service test***

***Initial Service test Condition***

The Initial Service Test will be carried out at the following operating condition:

*Table 1: Initial service test condition and acceptance criteria*

| Pressure | Flow | Acceptance Criteria |
|---|---|---|
| At separator operating pressure 10.8 barg | At 100% design flow (222 kg/s) | No leak in any connection and/or joint by visual inspection for minimum 10 minutes of holding IST pressure |

***Initial service test for SAGS***

The Initial service test shall be conducted for the complete SAGS system as shown in fig. 2. The critical valves inclusive of bypass valve in parallel are also described. The initial service test will be held for about 1 hour, the estimated time required to the check hte very long cross country lines. This is well in excess of the 10 minutes requirement by the code.

Before Initial service test, several cleaning and testing activities would have taken place. Therefore it is assumed:

- The safety barriers and sign boards left after the steam blow are in place and safety checks similar to steam blow have been carried out;
- The well pad production branch lines and other pipe requiring hydrostatic test have been completed successfully;
- The pipe lines and SAGS system have been checked during pre-commissioning stage;
- Use of the thermal pond rather than the main brine injection system during early steps;
- Use of the dry steam wells for the early steps to minimize the fluid handling issues at the thermal pond;
- All lines to be flushed and cleaned prior to being put into operation with thermal cycling several times to remove debris and mill scales;
- Avoiding leaving lines shut-down for long periods following cleaning, as this will tend to permit new corrosion, etc.
- Carry out at one time all activities requiring use of specific temporary facilities rather than having to dismantle facilities and reinstall them at some later stage;
- The SAGS has been started up and the warm up process has been completed (an operation done several times before during the flashing and steam blowing process);
- All the cross over and balancing lines between unit 1 and unit 2 SAGS have been isolated and the valves locked in the close position.

***Initial Service Test and Examination***

The line is heated up to100 degree centrigade with all vents and drains open i.e. under no pressure and then after the line temperature has established over the whole length, the vents and drains are throttled and the pressure raised gradually to the service test pressure.

ASME B31.1-2001 clause 137.7.2 when performing an initial service test, the piping system shall be gradually brought up to normal operating pressure and continuously held for minimum time of 10 minutes. Examination for leakage shall be made of all joints and connections. The piping system exclusive of possible localized instances at pump or valve packing shall show no visual of weeping or leakage.

The battery limit of the piping to be tested are

- Two phase cross country pipe line from specification break between high and low pressure piping system at each production well pad to separator inlets
- From Separator outlets to Scrubber inlets
- From Scrubber outlets to Turbine Inlets
- From Main Steam Header to Rock mufflers
- A short 24” brine line from the separator to an existing brine collection header

## SAFETY AND ENVIRONMENT IMPACT

The Contractor has overall responsibility for developing and implementing measures to ensure all IST activities are carried out in the safest possible manner, and in accordance with all safety related provision in the EPC contract and Indonesia

regulations. The Contractor shall prepare and submit for Owner review, specific safety procedures to be applied during major IST steps.
Safety measures shall include, but not be limited to:

- Prior notification of all local and statutory authhorities, residents, local workers and other project workers in the vicinity of the section of piping to be tested, advising the location of the procedure, timing, anticipated during and exclision zone.
- Notification as above once procedure has been completed.
- Provition of warning sign in english and bahasa Indonesia, road barriers and security personnel at a 500 m radius around any area where fluid is to be discharged during the procedure.
- Provision of safety traning to all personal involved in the procedure, regarding possible hazards.
- Provision of safety equipment – ear muffs, safety helmet, safety glasses/goggles, protective gloves- to all project personnel working on the procedure and within 500m of any discharge point.

Contractor shall provide a paramedic during IST activity. The paramedic team will be aavailable on site on a 24 hour basis to respond to any and all accidents. Communication system will be available so that paramedic can be readily contacted whenever required.
Safety equipment shall be provided safety to cater for possible toxic gas releases – e.g. hydrogen sulphide and carbon dioxide – and shall ensure personnel are trained in their use. Portable personal gas detection devices and least two sets of self contained breathing apparatus shall be available at any location where production fluid or geothermal steam is discharged to atmosphere. Adequate safety procedures are developed and implemented including :

- Work site evacuation procedures for gas releases, etc.
- Warning systems to notify workers of hazardous conditions
- Control measures for both vehicular and foot traffic, including roping or rencing off of the immediate test area.
- Electrical safety systems, such as circuit tagging for live/in-procces/dead, must be used by all on site.
- The MNL Well Opening Safety Checklist must be compled during well opening operations, as identified in the well SOP's.
- An MNL Permit to work (PTW) is required for work involving well location, hydrostatic testing, gas emission, radiography and blasting. This must be filled in by information on potentially dangerous activities to other work groups. The Owner's EHS group can advise on when this permit is required.
- The Sumitomo Safety Manual must be followed.
- Safety procedures for initial service and hydrostatictesting must be prepered and implemented. This must include a communication system so thet other site workers are awere when a test is taking place.
- Confined space Entry procedures and permit sytem must be followed for all work in confined spaces, including inside pipelines.
- Security shall be provided to prevent unauthorised acces and theft. Particular care shall ve taken to ensure the health and safety of local villagers are protected. This shall include suitable warning signs and systems, where required.

***Steam Field Hazard***

Known the steam-field hazards which may be encountered include:

- Hydrogen sulphide and carbon dioxide: These gases are normally found in geothermal production fluids and in the separated steam. Hydrogen sulphide is toxic, and carbon monoxide can act as an asphyxiant. Hydrogen sulphide are heavier than air and so tend to collect in low lying areas such as ellpad cellars. Use of portable gas detection equpment, testing of areas prior to entry and provition of self-contained breathing appartus are critical aspects of safety procedures.
- Burn and scalds: Fluid temperatures axceeding 200°C may be encountered during initial service test. Care must be taken to avoid contact any time fluid is discharged to atmaosphere and also to avoid touching hot metal surfaces, particularly piping which may not yet have had insualation fitted. Open drains, pond and sumps may contain water at up to 100°C.
- Flying debris: During initial service test solid debris can be expected to be discharged from the lines. Care must be taken as to where the discharged to ensure personnel and property are not at risk.
- Drowning: Care must be taken around ponds and sumps to avoid risk of falling in.

- Temporary piping: Care must be taken to ensure all temporary piping is adequately designed, constructed and supported for its intended service conditions. Any limitations on operating conditions must be clearly identified and adhered to.

***ENVIRONMENTAL***

Activities will be planned and executed so that they have the minimum environmental impact, and fully comply with all applicable provisions, in the EPCA, the project AMDAL permit and other Indonesian regulations.

Specific environmental issues which may arise include:

- Discharge of geothermal gases, including hydrogen suplhide gas, to atmosphere.
- Avoid discharge of liquid geothermal effluens to the environment. They are all to be collected and injected.
- Noise emissions.

Correct disposal of all wastes, including spilled liquid, will be managed. Liquids shall be deep injected, while solid hazardous wastes must be taken to the approved government dump.

Project public relations are of high importance. All complaints from local authorities will be addressed through the project owner. Housekeeping will be addressed on a daily basis.

For hydrogen sulphide discharge, the main source during initial service test will be from venting of steam to atmosphere, either from the normal SAGS steam vent system, or from temporary vent spools at other locations. The project AMDAL conditions provide an exemption on statutory H2S discharge limits for the commissioning period (up to a total of two months discharge duration). In practical terms, however, all discharges should be kept to the minimum time period and quantity required to complete the activity, since the discharged gas still presents a significant safety hazard.

There in no initial service test which part of commissioning period exemption provided under the AMDAL from the statutory noise limits of west Java which means that significant noise producing activities must be kept to minimum durations and preferably be carried out during day-time hours when the allowable limit is higher.

## INTERNATIONAL EXPERIENCE

Service Leak Tests are common practice for Geothermal Projects worldwide

**New Zealand:**

- Wairakei: Up to 1500 mm dia steam and 2-phase
- Ohaaki: 2-phase
- Mokai: 600 mm dia 2-phase
- Rotokawa: 2-phase
- Kawerau: 2-phase
- Ngawha: 2-phase

**Philippines:**

– Leyte: 600 MW development. Also in Tongonan, Negros and other PNOC sites
– PGI – Tiwi and Bacman

**Papua New Guinea:**

– Lihir: up to 1050 mm dia steam and 2-phase

**Kenya:**

– Olkaria II

**Nicaragua:**

– San Jacinto

## LESSON LEARNED

IST has been succcessfully applied in SAGS Wayang Windu unit 2 field, and the Project completed ahead of schedule and without Lost Time injury (2.3 million man hours).

Project owner could specify the initial service test for the SAGS two-phase and main steam and brine pipelines in their project requirement.

Initial service test could reduce time compare to Hydrostatic test. This task could be incorporate to facilitate initial power plant start-up as a preparation of initial start-up.

This techniques has reduced the EPC completion time and reduce the cost in term of civil work if compare to the hydrostatic testing.

Initial service test could be brough during the Hazard and Operability Study (HAZOP).

With the growing activities in geothermal activities, this best practice of initial service test could be proposed to EBTKE, as regulator, to consider and adopt it into their regulation regarding safety audit to installation, equipment and techniques used in geothermal activities.

## REFERENCES

PT Rekyasa Industri, Close out report of Wayang Windu Unit 2 geothermal power project, 2009

ASME B.31.1 para 137.3 Requirement for Specific Piping Systems
ASME B.31.1 para 137.2 Nonboiler External Piping
ASME B.31.1 para 137.7 for Initial Service Testing