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Portable Rock Muffler Tank for Well Testing Purpose

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ABSTRACT

During Unit 2 Drilling program in Wayang Windu Geothermal Power Plant, West Java, a well output test was conducted soon after a well was drilled. There are many purposes of well output tests, such as cleaning the well bore from remaining mud or dirt during drilling, determining the fluid chemical characteristic by fluid sampling, and determining the new well capacity.

The well testing process at Wayang Windu is designed for either two phase steam/brine or dry steam wells. Two phase wells are tested using a portable atmospheric separator vessel. This allows the brine to be separated from the steam and collected in a well site pond while the steam is discharged directly from the atmospheric separator. Noise emission is acceptable as two phase discharge produces less noise than dry steam. Dry steam wells which may contain small quantities of water and drilling mud are tested using a rock muffler to absorb the noise and avoid disturbance to the surrounding community and well site drilling operation.

Initially, well pads were constructed with permanent rock mufflers designed for well testing. These proved to be difficult to maintain and were determined to be more expensive than a portable rock muffler. If it's assumed the portable rock muffler is used in two well pads interchangeably, then the cost efficiency will be approximately 45%, while maintenance cost can be reduced up to 50%.

1. INTRODUCTION

Wayang Windu Geothermal Power Plant is operated by Star Energy Geothermal (Wayang Windu) Ltd. It is the first geothermal power plant with 110 MWe capacity in Indonesia. This power plant had its first commissioning by selling electricity to PLN (Indonesia's state electricity conpany) in May 2000.

Wayang Windu Geothermal Power Plant has its source of steam from Steam Above Ground System (SAGS) system. SAGS is designed to take produced two-phase geothermal fluid, separate it into clean steam and waste brine streams, convey the steam to the power generation (nominal 110 MWe) and convey separated brine and power station condensate to reinjection, all in a manner that is safe, controlled, and environmentally acceptable.

SAGS system consists of components such as production well pads, injection well pads, two phase main lines, separator station, steam piping, steam venting system, scrubber station, brine injection system, condensate injection system, wash water system and field instrument air supply.

1.1 Rock Muffler

In addition to the SAGS rock muffler for the steam venting system in vent valve station area, there were small rock mufflers constructed permanently in each well pad that have wells categorized as dry wells, such as in the MBD, MBE, MBA and MBB well pads. This rock muffler is used to vent steam to atmosphere under pressure control for well testing purpose, whereas SAGS rock muffler can reduce noise emission during steam flowing to atmosphere following a turbine trip.

A portable rock muffler has an inlet pipe which is connected to a header pipe with many distributing pipes located below many layers of rocks inside the rock muffler pit. The well testing pipe is connected to the inlet pipe so the steam will flow to the rock muffler pit and pass through many layers of rocks to the atmosphere. The noise level recorded on this portable rock muffler is typically about 90 dBA compared to the use of a permanent rock muffler, which was about 80 dBA, while noise WHO threshold is 85 dBA for 8 working hours/day.

1.2 Rock Muffler Design Criteria

In designing the rock muffler, there are some criteria with engineering and environmental aspects to be considered.

Criteria from engineering aspects are as follows:

- Flow capacity should be considered to avoid erosion effect and choke effect (covered by velocity analysis study).
- Proper material selection for long term operation (covered by mechanical strength analysis study).
- The foundation of rock muffler must be able to withstand weight load of rocks.
- The pipe should be easy to maintain due to corrosion and erosion effect.

Criteria from environmental aspect are as follows:

- Noise emission and proximity to inhabited areas
- The potential for accumulation of Non Condensable Gas (NCG) including hazardous concentrations of H2S in the system
- The needs to avoid steam clouds drifting over access roads, transmission lines, and local communities.

2. UNIT 2 WELL TESTING PROGRAM

During the Unit 2 Drilling program in Wayang Windu Geothermal Power Plant, West Java, a well output test was conducted soon after the well had been drilled. There are

many purposes of well output tests, such as cleaning the well bore from remaining mud or dirt during drilling, determining fluid chemical characteristics by fluid sampling, and determining the new well capacity.

The well testing process at Wayang Windu was designed for either two phase steam/brine or dry steam wells. Two phase wells are tested using a portable atmospheric separator vessel. This allows the brine to be separated from the steam and collected in a well site pond while the steam is discharged directly from the atmospheric separator. Noise emission is acceptable as two phase discharge produces less noise than dry steam. Dry steam wells, which may contain small quantities of water and drilling mud, are tested using a rock muffler to absorb the noise and avoid disturbance to the surrounding community and well site drilling operations.

Unit 2 new wells and make up wells were categorized as dry steam wells, so the well testing team used a permanent rock muffler for the purpose of well testing. The rock muffler was constructed in a pit, which was lined with stone masonry. However, due to high well output, the existing rock muffler capacity was not sufficient to test the well at full flow and maintenance was difficult and expensive. The rocks had to be routinely removed from the rock pit in order to remove mud and repair the stone masonry.

2.1 Propose of Portable Rock Muffler

The construction of a portable rock muffler using a water tank was proposed to solve the issue. The inlet pipe, complete with the header and distributing pipes, were fabricated and installed inside the tank. The tank was filled with porous rocks to reduce the produced noise level. This work can be conducted in short time using available materials in the field, and it can fulfill criteria standard of environmental aspect.

3. ENGINEERING STUDY

A portable rock muffler has an inlet pipe, which is connected to a header pipe with many distributing pipes located below many layers of rocks inside the rock muffler tank. The well testing pipe is designed to be connected to the inlet pipe, so the steam will flow to the rock muffler and pass through many layers of rocks to the atmosphere. See the photographs of the muffler tank (and see Figure 1a & b) and the Well Testing Schematic using Rock Muffler (Figure 3).

Two aspects of the rock muffler design had to be analyzed – velocity analysis and strength analysis.

3.1 Velocity Analysis

For pipe sizing, velocity analysis is conducted to assure fluid velocity will not cause pipeline erosion which will shorten operating life of the pipeline. For orifice hole sizing, velocity analysis is conducted to obtain the required pressure for pushing the steam out through the holes with specified mass flow rate. Another consideration is that the rock muffler will exhaust steam which has certain mass flow rate and velocity to drag the rocks. Therefore, the drag force produced should not exceed the rock's gravity force to make sure the rock will not be thrown away from the rock muffler tank.

For MBB#1 well testing case, by assuming the median pipe pressure rate during well testing line is 14 bars in 12" Sch. 40 API 5L Gr. B pipe with mass flow rate is 40 kg/s, the calculated steam velocity is 73 m/s. Although this velocity is still above maximum velocity limit for dry steam of 60 m/s as stated in process design criteria by Wayang Windu SAGS designer, the velocity is still considered acceptable considering the short term well testing duration. Routine intensive pipe thickness monitoring was completed to assure the pipeline reliability.

Orifice hole sizing was performed iteratively. With upstream pressure of 1.43 bara at header pipe and down stream pressure of 1 bara, the diameter of orifice hole is 30 mm with total mass flow rate is 40 kg/s (or 144 ton/ hr) for 398 holes. The velocity in each hole is about 172 m/s (see calculation in Table 1).

By assuming open area of rock muffler tank is 20% and using coefficient of drag (Cd) of 2 and rock density of 2500 kg/m^3 with diameter (sphere type) of 200 mm, the calculated drag force is 5.3 N. This drag force is still much lower than rock's gravity force of 102.7 N. Further calculation is conducted using a rock diameter of 20 mm; the calculated drag force is 0.05 N. This drag force is still lower than rock's gravity force of 0.10 N (see calculation in Table 2). Thus, it is concluded that rocks should not be discharged from the tank providing it is greater than 20mm in diameter.

3.2 Strength Analysis

Strength analysis was conducted to assure a fluid pressure below the limit of design pressure in order to have a long operating life. Pipe bursting pressure of 12 in Sch. 40 API 5L Gr. B material is 92.4 bar, which is much higher than shut in pressure of well (35 bar).

4. PORTABLE ROCK MUFFLER VS. PERMANENT ROCK MUFFLER

Comparison between a portable rock muffler and permanent rock muffler is studied in some aspects as follows:

- Noise Measurement
- Economic Analysis
- Maintenance and Flexibility

The noise level recorded on this portable rock muffler is typically about 90 to 100 dBA at a radius of 5 m compared to the use of permanent rock muffler, which was about 80 - 90 dBA, while noise WHO threshold is 85 dBA for 8 working hours/day. Noise measurement in the adjacent community was below 60 dB, as stated in geothermal environmental policy. Figures 4 & 5 below show noise and H_2S monitoring during MBB#1 and MBA# 3 well testing, respectively.

The cost of constructing a portable rock muffler is almost the same of constructing a permanent rock muffler. This high cost of the portable rock muffler is due to construction cost in mechanical work, and the high cost of a permanent rock muffler is caused by construction cost in civil work. See Table-3.

A portable rock muffler tank has a lower maintenance cost than a permanent rock muffler, which is caused by easier working access which will reduce man hours. Besides, the high flexibility of using a portable rock muffler should be included because a portable rock muffler can be moved to another well pad for well testing purposes. If it is assumed that the portable rock muffler is used in two well pads interchangeably, then the cost efficiency will be

approximately 45%, while the maintenance cost can be reduced to 50%. Figures 2a & 2b illustrate the use of portable rock muffler for well testing.

CONCLUSION & RECOMMENDATION

Some conclusions and recommendation are made for this project as follows:

- The portable rock muffler can be used for well testing purposes in dry wells. However, velocity limits should be considered, which depends on well flow capacity. Further study of portable rock muffler design is recommended.
- The portable rock muffler can effectively reduce noise emission.
- The portable rock muffler can be used interchangeably due to its flexibility and ease of maintenance.
- A portable rock muffler tank has a lower maintenance cost than a permanent rock muffler due to easier working access, which reduces man hours.
- Periodic pipe thickness measurements are recommended to assure reliability of portable rock mufflers and well testing pipework.

ACKNOWLEDGEMENT

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Figure 1a : Inside View of Portable Rock Muffler Tank

Figure 1b: Outside View of Portable Rock Muffler Tank

Figure 2a: Well testing at MBB well pad

Figure 2b: Well testing at MBA well pad

TABEL 1

Hole sizing as per orifice equation ex Crane Page 2-14.
q=YCAx(2dPVg)^.5 Note: P in N/m2
Assume ratio of orifice to pipe (beta) = 0.2

Description		Unit
Beta	0.20	
C	0.59	
Upstream Pressure	1.43	bara
Pressure Downstream	1.00	bara
Corrected downstream Pressure	1.00	bara
Delta Pressure dP	0.43	bar
Pressure Ratio dP/P'	0.30	
Y as per A21	0.91	
Specific Volume	1.21	m3/kg
Diameter of hole	30.00	mm
Flow per hole	0.12	m3/sec
Flow per hole	0.36	t/hr
Velocity in hole	172.47	m/s
Flow Required	144.00	t/hr
Holes required	398.00	ea

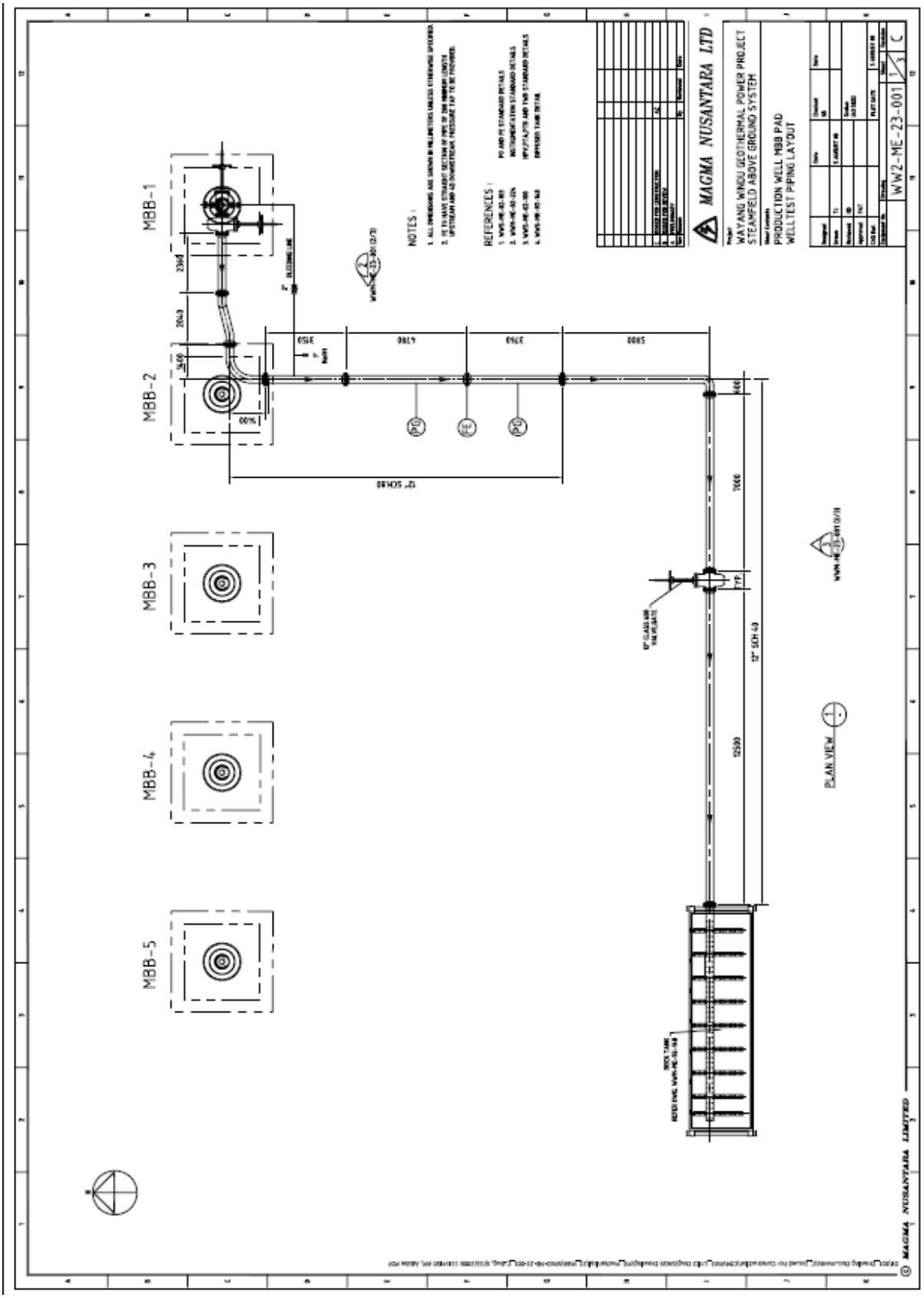

Figure 3: Well Testing Schematic at MBB-1 using Portable Rock Muffler

TABEL 2

Description	For d = 200mm	Unit	For d = 20mm	Unit
Steam Flow	144.00	t/hr	144.00	t/hr
Area of centre portion	20.00	m2	20.00	m2
Cd	2.00	kgm/s2	2.00	kgm/s2
Plain velocity	3.39	m/s	3.39	m/s
Open Area	0.20		0.20	
Velocity	16.94	m/s	16.94	m/s
Steam Density	0.59	kg/m3	0.59	kg/m3
Diameter sphere (Rock)	0.20	m	0.02	m
Rock Density	2,500.00	kg/m3	2,500.00	kg/m3
Gravity	9.81	m/s2	9.81	m/s2
Drag	5.32	N	0.05	N
Gravity Force	102.74	N	0.10	N

TABEL 3

Description	**Portable Rock Muffler (USD)**	**Permanent Rock Muffler (USD)**
Mechanical Work	55,000	20,000
Civil Work	0	30,000
Rock Filling	2,000	3,000
Maintenance Cost	3,000	4,000
Mobilization Cost	2,000	0
Total	**62,000**	**57,000**
Total Cost for 2 well pads	**62,000**	**114,000**

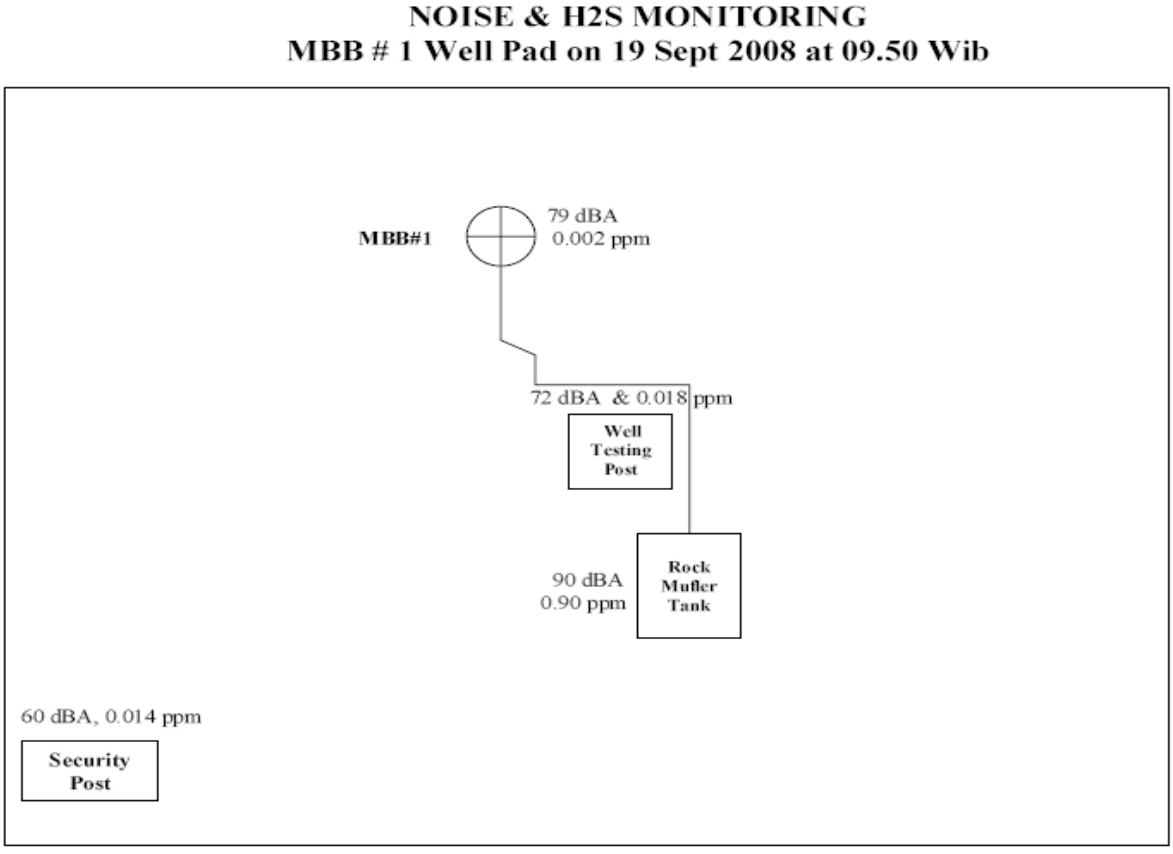

Figure 4: Noise & H2S Monitoring of MBB#1 Well Testing

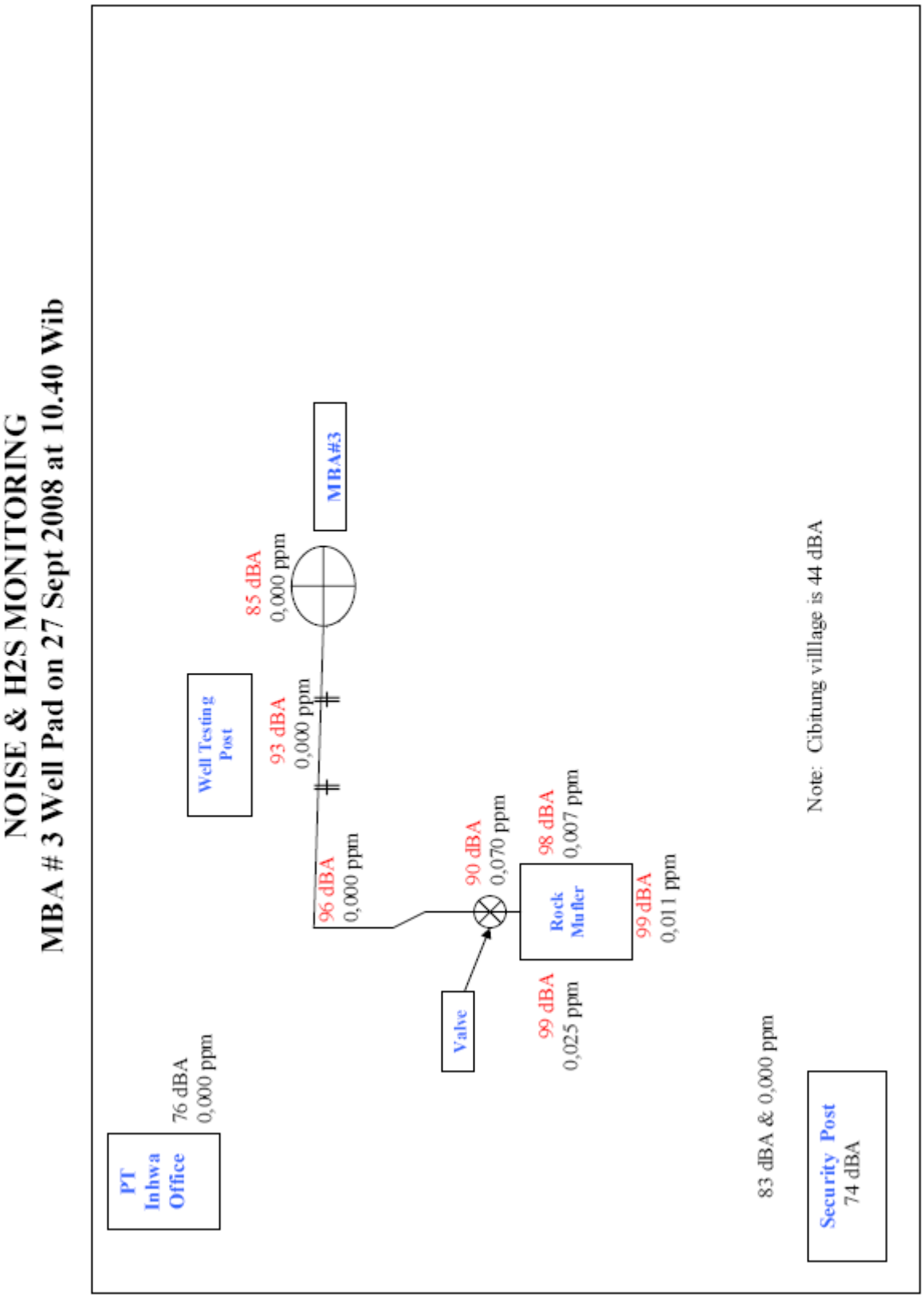

Figure 5: Noise & H2S Monitoring of MBA#3 Well Testing