Reliability, Availability, Maintainability Analysis

CO_2 Capture Facility

Kårstø, Norway

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Contents

Reliability, Availability, Maintainability (RAM) Analysis

1.0 PURPOSE

The CO2 carbon capture amine plant at the proposed commercial scale is considered the first-of-the-kind application for the amine based scrubbing technology. At the present time, the largest amine scrubber for flue gas application is about 1000 tpd capacity. The proposed Karsto facility has a capability of about 3100 tpd. This RAM analysis provides a quantitative assessment on the reliability of the system

2.0 METHODOLOGY

The methodology used in assessing the reliability of the amine plant is based on the traditional RAM analysis provided for power plants. The plant is first divided into systems, and a reliability block flow diagram is constructed to depict the system configuration. Each block is then further broken down into components. Figure 1 is the overall reliability block flow diagram for the proposed amine plant. The system is divided into seven systems as follows:

- Direct contact cooler
- Flue gas blowers
- Absorber Tower
- Stripper Tower
- Compressor and dryer
- Send out pumps
- Balance of plant

The reliability of each system is then calculated based on its configuration and component reliability data. The reliability of the entire plant is the aggregate of all seven systems.

Note that the reliability loss is mainly from rotating equipment. The absorber tower and stripper tower have stationary packing in them. These packing materials may foul or degrade over long period of time, but they do not cause sudden plant outages. The effect of tower internals such as trays and packing is not included in this assessment. Since the towers are constructed with stainless steel materials, their failure due to metal corrosion is also not considered here.

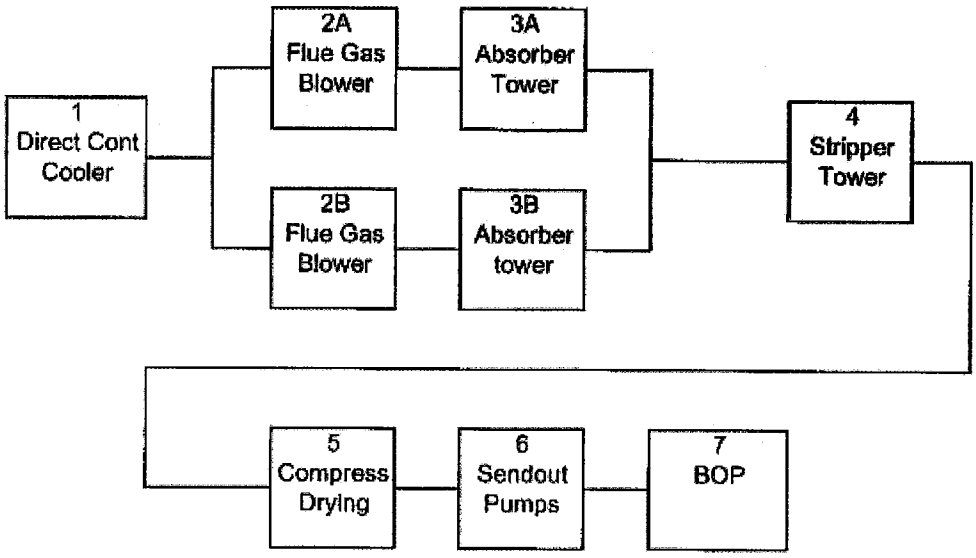
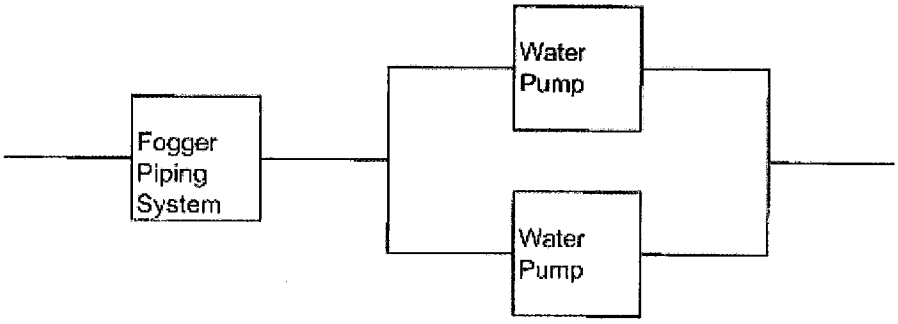
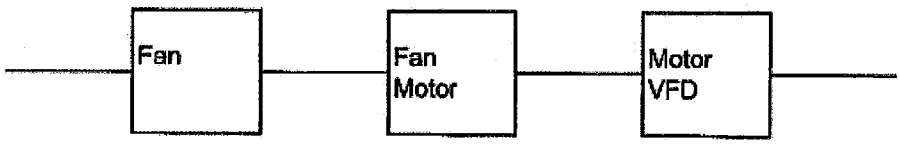


Figure 1 Overall Reliability Block Diagram

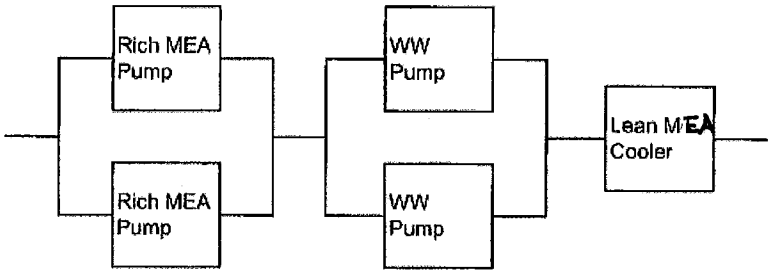
System reliability block flow diagrams for all seven systems are shown below:



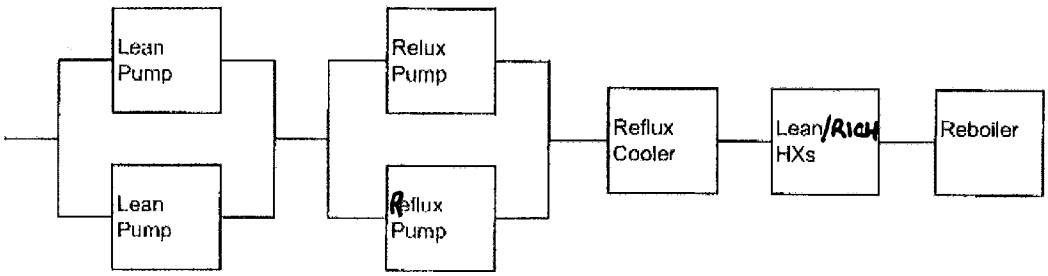
System 1- Direct Contact Cooler



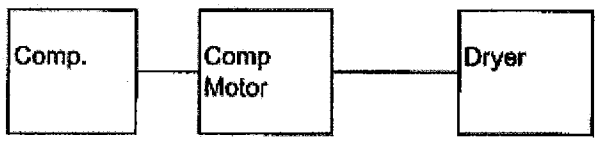
System 2- Gas Blower



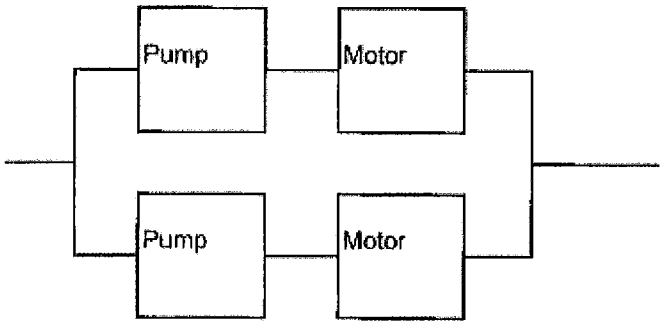
System 3- Absorber tower



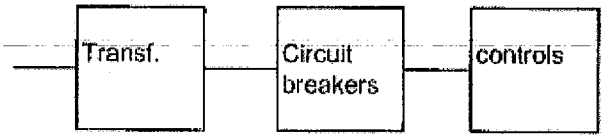
System 4- Stripper Tower



System 5 Compressor/Dryer



System 6- Send out pumps



System 7- BOP

3.0 SCOPE

Table 3.0-1 shows the component reliability data for each of the major components identified on system block diagrams. The definition of component reliability data is as follows;

MTBF – mean time between failures
MTTR – mean time to restore

Reliability number = MTBF/(MTBF+MTTR)

The component reliability data are obtained from the following sources:

- North American Reliability Council (NREC)'s Generating Availability Data System (GADS)
- IEEE Standard 493-2007
- Paper citing OREDA data on compressors

Table 3.0-1 Component Reliability Data

System	Component	Failur rate per unit year	MTBF	MTTR	Reliability	Source
1	Fogger		2240000	8	1.0000	IEEE
	Water pump	0.01	876000	24	1.0000	
2	Blower Fan	1.2	7300	24.5	0.9967	GADS ID fan
	Fan motor	0.47	18638	20	0.9989	GADS ID fan
	Variable speed dr.	0.04	219000	15	0.9999	GADS ID fan
3	Rich amine pump	0.01	876000	158	0.9998	
	Water pump	0.01	876000	24	1.0000	
	Lean amine cooler	0.01	876000	4.5	1.0000	
4	Leam amine pump	0.01	876000	158	0.9998	
	Reflux pump	0.01	876000	158	0.9998	
	Reflux cooler	0.01	876000	4.5	1.0000	
	Lean/Rich HX	0.01	876000	4.5	1.0000	
	Reboiler	0.028	306600	28	0.9999	
5	Compressor		60606	30	0.9995	OREDA/GADS
	Compressor motor	0.11	79636	36	0.9995	
	Dryer		3831360	5	1.0000	
	Compressor overhaul		17520	168	0.9905	1 weeks every 2 yrs
6	Send out pump	1.7	5153	30	0.9942	GADS Use BFP data
	Pump motor	0.33	26545	58	0.9978	GADS Use BFP data
7	Transformer	0.0041	2136585	378	0.9998	IEEE
	Circuit Breakers	0.0052	1684615	32	1.0000	
	Controls		10345	3.68	0.9996	IEEE

Table 3.0-2 shows the reliability of each of the seven systems:

Table 3.0-2 System Reliability

System	Equipment Name	With compressor scheduled outage	Without compressor scheduled outage
1	Direct contact cooler	1.0000	1.0000
2	Flue gas blowers	0.9955	0.9955
3	Absorber Tower	0.9998	0.9998
4	Stripper Tower	0.9995	0.9995
5	CO2 Compressor/dryer	0.9896	0.9991
6	Sendout pumps	0.9999	0.9999
7	Balance of Plant equipment BOP	0.9994	0.9994
Total		0.9839	0.9933

4.0 DISCUSSION

4.1 Reliability and Availability

In most flue gas MEA based amine plants, the reliability losses are mainly due to amine degradation associated with amine solvent. Degradation of amine can lead to equipment corrosion. In the Bechtel proposed design, stainless steel vessels, heat exchangers, and piping are used. Pumps that handle amine are made of SS materials as a counter measure for corrosion. As a result, the common corrosion problems associated with other MEA based processes do not apply in the process offered here.

Table 3.0-2 shows an overall plant availability of 98.39% including a one-week of compressor outage every two years. If this outage can be scheduled to coincide with the power plant outage, the CO2 plant reliability is increased to 99.33%.

4.2 Maintainability

The design of CO2 plant has taken maintainability into consideration. All pumps are equipped with a 100% installed redundant unit. The compressor unit does not have a redundant equipment due to its high cost. However, site storage of critical spare parts, such as the compressor seals as well as electrical control spare parts, along with regular maintenance should render this a high reliability equipment.