Achieving Reliable Operations by Implementing Maintenance Program for Critical Valves

Leonardo Castarlenas

SWIMD - Sea Water Injection Maintenance Division
Reliability Unit - Reliability Engineer for Valves
S. Admin. Bldg., Mubarraz; Phone +966-13-5772116
leonardo.castarlenasmir@aramco.com

Mustafa Alali (coauthor)

SWIMD - Sea Water Injection Maintenance Division
Reliability Unit – Catalguing Especialist - Valves
S. Admin. Bldg., Mubarraz; Phone +966-13-5771053
mustafa.alali@aramco.com

ABSTRACT

A comprehensive Maintenance Program for critical valves, implemented by Saudi Aramco Sea Water Injection Department (SWID) back in 2014, has shown remarkable achievements, counting 216 critical valves repaired and upgraded for total cost savings of 9.2 MM USD, with a forecast of 3.0 MM USD savings for the next three years cycle, demonstrating that integrated efforts towards valves' reliability are not only practical, but extremely profitable.

Key words: Maintenance program; critical valves; obsolescence; local manufacturing; non-metallic valves; sea water.

INTRODUCTION

The integral approach of the Maintenance Program for critical valves has motorized the change to a maintenance driven culture that includes updated and reliable data, improved maintenance planning by cataloguing spare parts, local manufacturing, upgraded materials deployment, including non-metallics, in-house training of new generations, preventive maintenance implementation, and, detailed and customized repair plans suited for each particular application and needs.

BACKGROUND

Saudi Aramco Sea Water Injection Department's mission is to treat, transport & inject sea water to support and sustain crude oil and gas production in a safe, efficient and environmentally responsible manner, utilizing a qualified and highly motivated workforce and appropriate technologies. SWID has the largest seawater treatment plant in its kind, with a design treatment capacity of 14 million bpd, and it ships large amounts of treated seawater by a massive transfer pipeline network (60" & 56") to downstream booster and injection facilities, servicing the Ghawar, Harad, and Khurais oilfields.

Former "run to failure" maintenance strategy in regards to valves, originally developed for newly installed equipment, became impractical after lifecycles reached maturity levels, mainly because such policy did not distinguish among critical and non-critical equipment, being the major challenge, how to respond quickly to critical valves' failures. Such situation, heavily undermined SWID's piping isolation flexibility. Maintenance planners had to deal with the high cost of replacing valves, long lead times in manufacturing & delivery, and long processing/justification/approval times. Therefore, the situation required to be addressed by a comprehensive maintenance approach for critical valves heavily addressed to integrity & reliability enhancement.

PROGRAM DEVELOPMENT AND IMPLEMENTATION

It is a stage-based program that has included foundational work (field survey & database creation), maintenance planning, and valve management strategy development, with the aim of keeping such defined schemes as a powerful driver to sustain reliable operations of critical valves. The program has more than six years of successful implementation and results.

Phase I - Foundational Work

1. Criticality assessment for establishing criticality levels, and prioritizing accordingly (based on SABP-G-017 Equipment Criticality Assessment)

2. Identify critical valves & actuators at SWID from facilities P&IDs:

   A total of 1405 critical valves identified. Figure 1 illustrates the critical valves breakdown by SWID facilities:

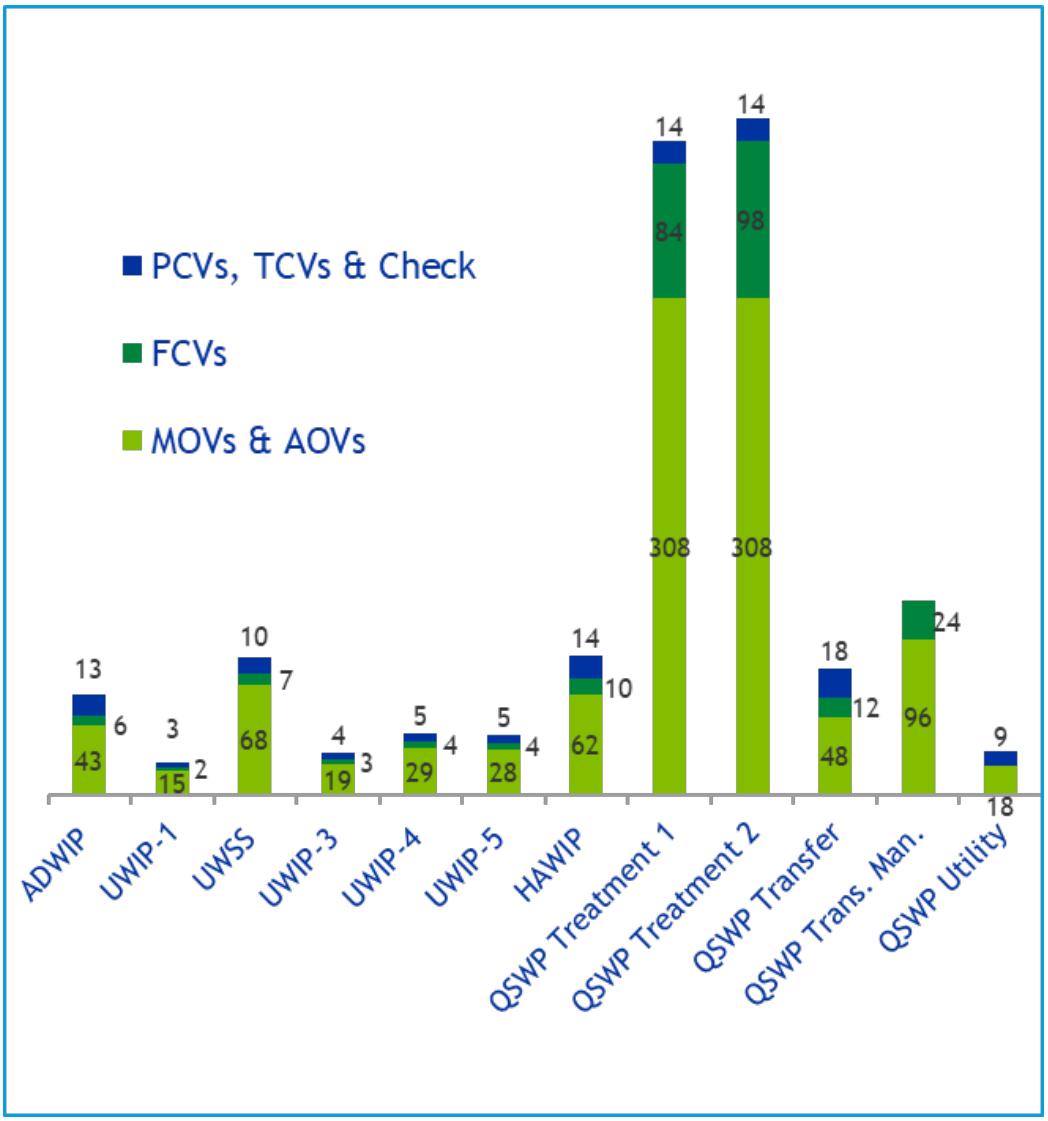


Figure 1: Critical valves identified at SWID facilities

A total of 1319 critical actuators identified. Figure 2 illustrates the critical actuators breakdown by SWID facilities:

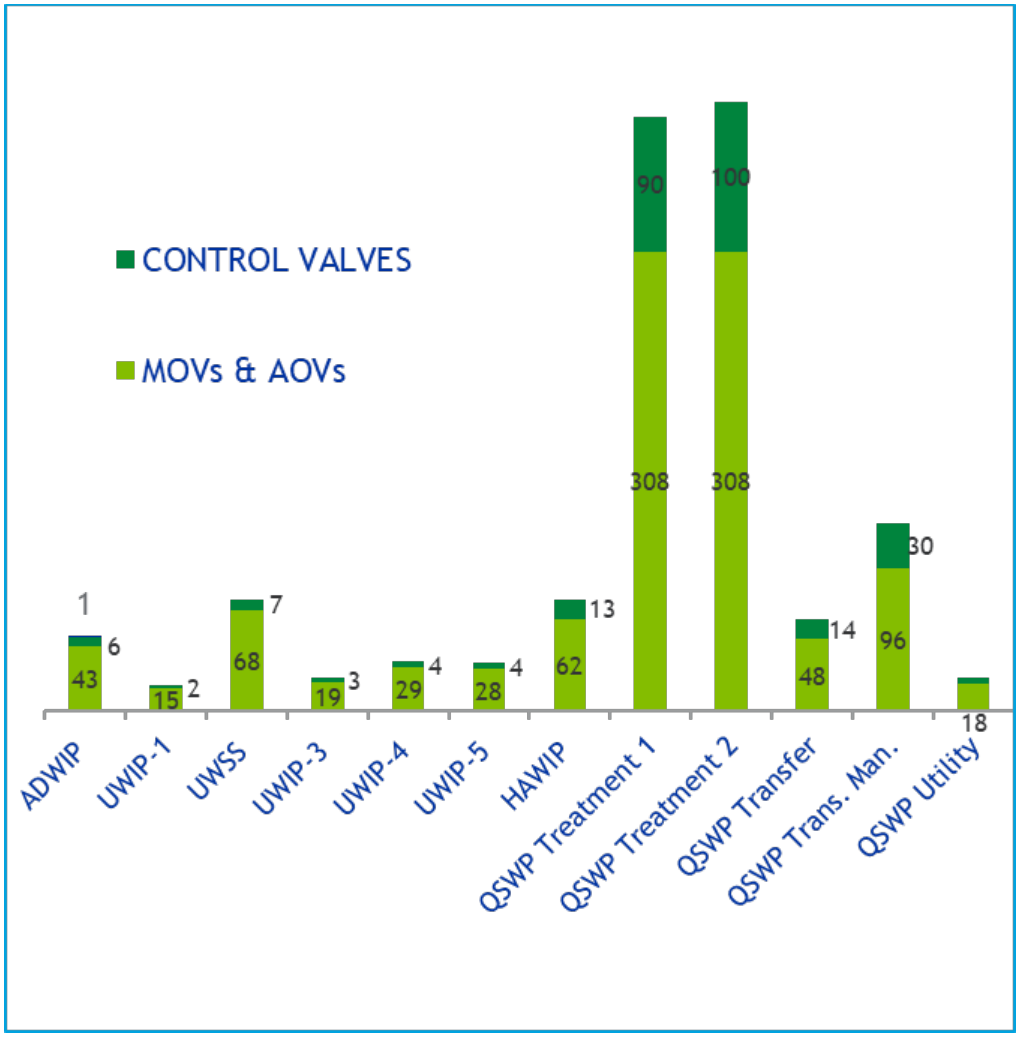


Figure 2: Critical actuators identified at SWID facilities

3. Field survey: Retrieving data from existing equipment

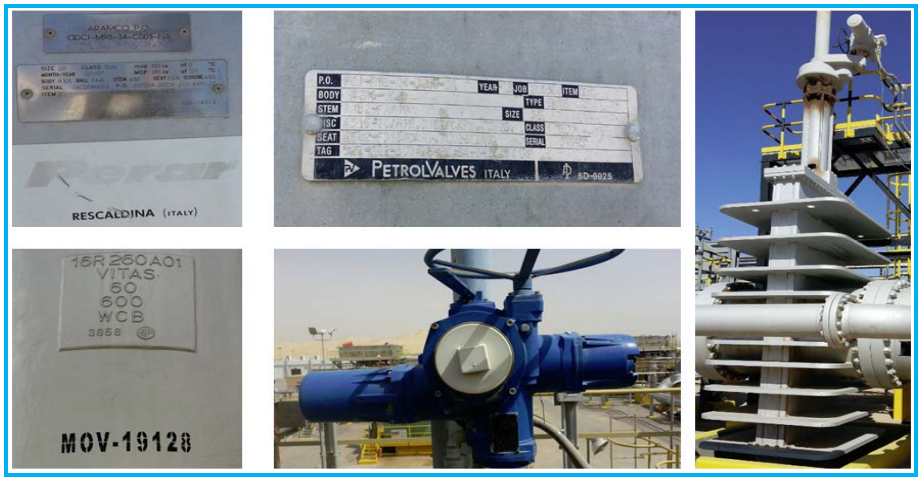


Figure 3: Field survey - nameplates

4. Database and interchangeability records creation: Systemic organization of data, including interchangeability among SWID facilities for future repair plan setting up, as well as, establishing contingency plans

Figure 4: Interchangeable valves at SWID facilities

Phase II – Maintenance Planning Enhancement

1. Spare Parts Cataloguing: Comprehensive plan for cataloguing spares for valves and actuators

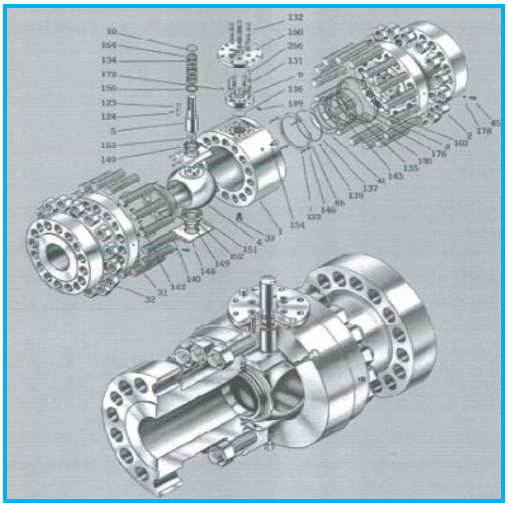


Figure 5: Ball valve components

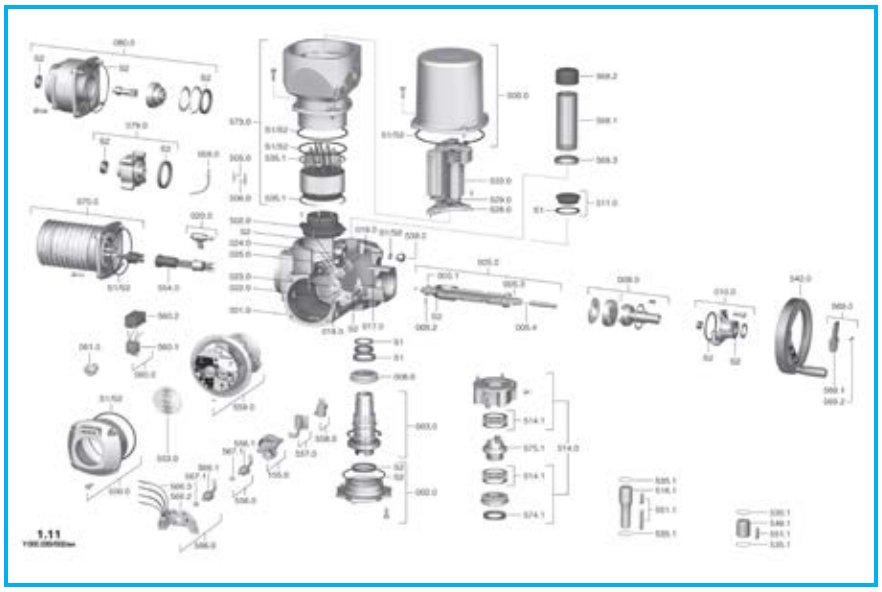


Figure 6: Electrical actuator components

2. Identification of obsolete equipment:
   - A total of 387 critical valves identified as obsolete (21%)
   - A total of 444 critical actuators identified as obsolete (34%)

3. Implementation of preventive maintenance plans for isolation valves: In line with maintenance driven culture, a complete set of PM Manuals were developed by SWID maintenance personnel, then successfully implemented since 2017 (refer to Figures 7 & 8)

Figure 7: Ball valve's cavity venting/draining & flushing application

Figure 8: Seat cleaning & greasing application over ball valve

Phase III – Repair Plans & Reliability Enhancements

1. Condition Assessments & Root Cause Analysis: Upon completion of databases, obsolescence identification, and the continuous efforts in regards to cataloguing spare parts for critical valves and actuators, next phase started by conducting a deeper survey that included the condition of valves and actuators. Furthermore, such condition assessments have been combined with root cause analysis sort by valves' types towards development and implementation of effective maintenance plans.

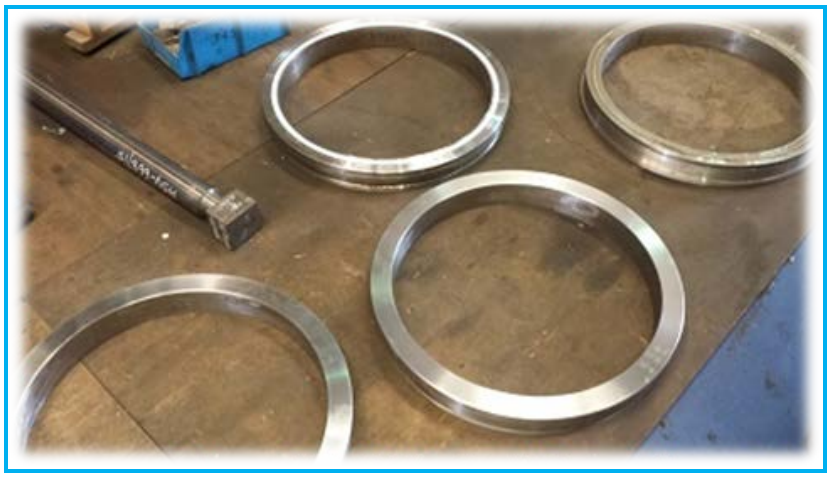
Figures 9 & 10 show typical failures of materials exposed to sea water service

2. Establish customized repair plans segregated by valve type, and defects/damages: Successful development and implementation of customized repair plans and procedures, based upon root cause investigations, grouped by valves' type to increase the efficiency of such implementation. Moreover, named plans have been addressed to the priorities established on Phase I. After six years of program implementation, 216 critical valves have been successfully repaired and upgraded for total cost savings of 9.2 MM USD.

Figure 11: Ball valves repair and upgrade

Figure 12: A number of repaired valves under program's umbrella

3. Overcoming obsolescence issues – reverse engineering - spare parts local manufacturing: Extensive sessions along with local contractors, and raw materials suppliers have been carried out, concluding in a challenging plan for locally manufacturing obsolete components for isolation and control valves, including hard and soft components.



Figures 13 & 14 show internal locally manufactured components for isolation and control valves

4. Overcoming obsolescence issues – deploying new electric actuators: The modernization of electrical actuators fleet is ongoing, having deployed 108 units so far.

Figures 15 & 16 show newly deployed electrical actuators at SWID facilities

5. Deploying non-metallic materials – valves: Massive deployment Plan of valves manufactured with non-metallic materials have taken place since 2018, as a part of corrosion mitigation initiatives over different chemical services and sea water as well, having deployed more than 400 valves so far, including composite[(1)] Polytetrafluoroethylene (PTFE) lined valves, Polysulfone[(2)] glass fiber reinforced resin valves, etc.

Figures 17 & 18 show non-metallic made valves right before its installation

CONCLUSIONS

- Founded upon a reliable database, the program's platform has allowed SWID to take control over its critical valves, by means of developing and implementing effective maintenance plans for each kind of valve. The program's major pillars include: spare parts cataloguing, customized repair procedures, and maintenance planning.

- Establishing strong ties with manufacturers was crucial for backing up the program's ambitious spare parts cataloguing plan, having successfully achieved a total of 1,080 equipment items (valves and actuators), representing 16,487 parts catalogued to date

- The implementation of repair & upgrade plan for critical valve counts 216 critical valves repaired and upgraded for total cost savings of 9.2 MM USD, with a forecast of 3.0 MM USD savings for the next three years cycle

- A considerable reduction of 30%, on failure rates of isolation valves, has been led by the implementation of preventive maintenance activities (seat cleaning/greasing, body cavity draining & flushing).

- Deployment of non-metallic valves, is a powerful driver for eliminating corrosion at low pressure applications (up to 150 psig), having shown remarkable "zero failures" rate, during the first trial year.

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(1) A Composite Material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. [2]

(2) Polysulfones are a family of thermoplastic polymers. [3]

ACKNOWLEDGEMENTS

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GLOSSARY OF TERMS & ACRONYMS

The following terms and/or acronyms are used herein:

- ADWIP — Ain Dar Water Injection Plant
- AOV — Air Operated Valves (Pneumatic Actuator)
- Check — Non-return valves / check valves
- FCV — Flow Control Valve
- HAWIP — Hawiyah Water Injection Plant
- MOV — Motor Operated Valves
- P&ID — Process and Instrumentation Diagram
- PM — Preventive Maintenance
- PCV — Pressure Control Valve
- QSWP — Qurayyah Sea Water Plant
- QSWP Transfer — Qurayyah Sea Water Plant – Transfer Area
- QSWP Trans. Man. — Qurayyah Sea Water Plant – Transfer Area Manifolds
- QSWP Treatment 1 — Qurayyah Sea Water Plant – Treatment Area 1
- QSWP Treatment 2 — Qurayyah Sea Water Plant – Treatment Area 2
- QSWP Utilities — Qurayyah Sea Water Plant – Utilities Area
- SABP — Saudi Aramco Best Practice
- SWID — Sea Water Injection Department
- TCV — Temperature Control Valve
- UWIP-1 — Uthmaniyah Water Injection Plant 1
- UWIP-3 — Uthmaniyah Water Injection Plant 3
- UWIP-4 — Uthmaniyah Water Injection Plant 4
- UWIP-5 — Uthmaniyah Water Injection Plant 5
- UWSS — Uthmaniyah Water Supply Plant

SHARING KNOWLEDGE / PARTICIPATION IN MAINTENANCE & RELIABILITY EVENTS

1. **2017 PD&T Technical Exchange Forum** – Saudi Aramco Pipeline Distribution & Terminals Department, November 29, 2017, Khobar, Kingdom of Saudi Arabia.

2. **2018 Valve Reliability & Integrity Forum** – Saudi Aramco Southern Area Pipelines Department, February 6, 2018, Abqaiq, Kingdom of Saudi Arabia.

3. **17th Middle East Corrosion Conference & Exhibition** – Bahrain Society of Engineers & NACE International, September 30th to October 3rd 2018, Manama, Kingdom of Bahrain.

4. **Preventive Maintenance for Isolation Valves Seminar** - Saudi Aramco Sea Water Injection Department, November 08, 2018, Al-Hassa, Kingdom of Saudi Arabia

5. **2018 Maintenance and Reliability Forum** – Saudi Aramco Western Region Distribution Department, November 21, 2018, Jeddah, Kingdom of Saudi Arabia.

6. **2019 SWID Valves Maintenance Roundtable Workshop** - Saudi Aramco Sea Water Injection Department, December 17, 2019, Al-Hassa, Kingdom of Saudi Arabia

7. **VALVE-CON 2019 Valve Integrity & Reliability Management Conference and Exhibition** – Saudi Aramco Southern Area Pipelines Department, December 11-12, 2019, Khobar, Kingdom of Saudi Arabia.

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