Retrofitting of SOx Exhaust Gas Cleaning Systems

Latest developments and Technical Challenges

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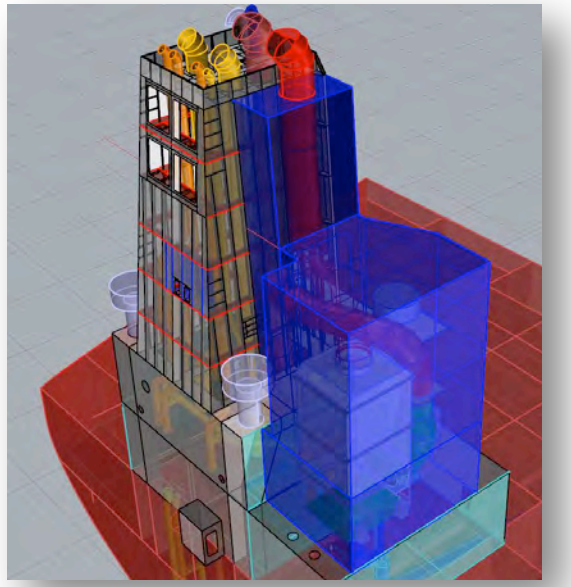
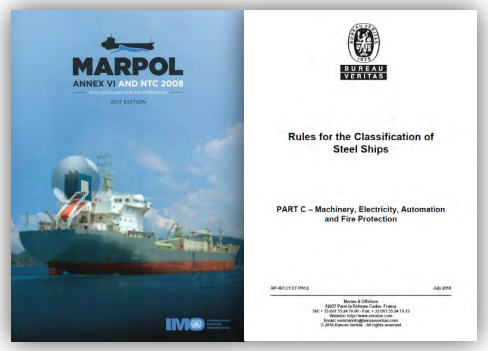
Shortsea Shipping Forum 13-6-2019

Agenda



01

World Fleet Retrofit status update



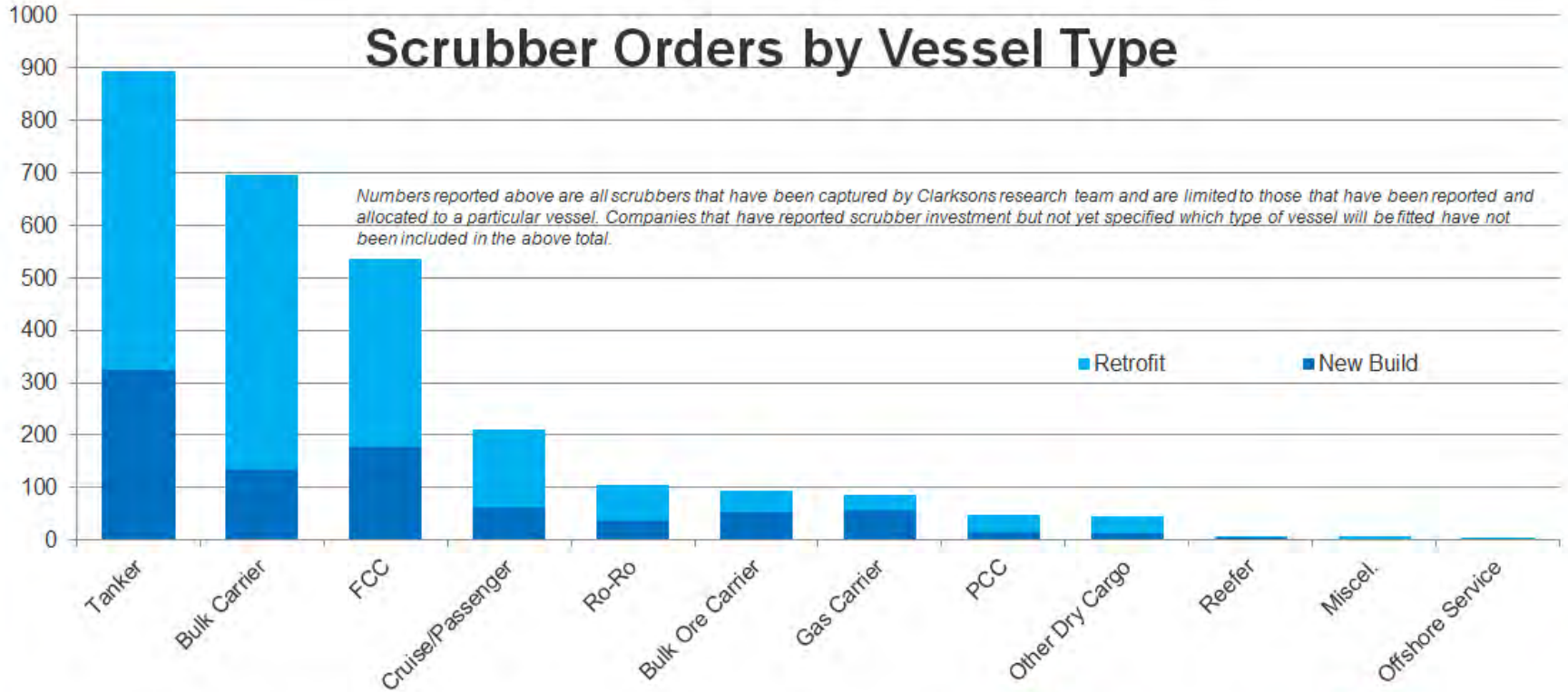
02

Technical challenges during EGCS certification

CLARKSONS SCRUBBER UPDATE

Current Situation June 6th 2019

Expected Scrubber Uptake By Vessel Class and Build



- Scrubber uptake as captured by Clarksons Research team

Build	Scrubbers
New Build	885
Retrofit	1849
Grand Total	2734

Vessel Group	Scrubbers
Tanker	894
Bulk Carrier	695
FCC	537
Cruise/Passenger	210
Ro-Ro	105
Bulk Ore Carrier	94
Gas Carrier	86
PCC	49
Other Dry Cargo	46
Reefer	7
Miscel.	7
Offshore Service	4
Grand Total	2734

Type	Scrubbers
Open Loop	1177
Unspecified	1052
Hybrid	453
Closed Loop	52
Grand Total	2734

CLARKSONS SCRUBBER UPDATE

Dry Bulk	Scrubbers	Total Fleet	% of Fleet
Capesize 100,000+	384	1723	22.29%
Panamax 65-100,000	179	2554	7.01%
Handymax 40-65,000	193	3613	5.34%
Handysize 10-40,000	57	3410	1.67%
Total	**813**	**11300**	**7.19%**

Tankers	Scrubbers	Total Fleet	% of Fleet
VLCC 200,000+	239	729	32.78%
Suezmax 125 -200,000	143	568	25.18%
Aframax 85 -125,000	173	1000	17.30%
Panamax 55 - 85,000	21	457	4.60%
Small 0 - 55,000	318	3925	8.10%
Total	**894**	**6679**	**13.39%**

Containers	Scrubbers	Total Fleet	% of Fleet
15,000+ teu	60	120	50.00%
12 - 14,999 teu	97	236	41.10%
8 - 11,999 teu	135	619	21.81%
6 - 7,999 teu	27	270	10.00%
3 - 5,999 teu	56	1093	5.12%
100-2,999 teu	162	2937	5.52%
Total	**537**	**5275**	**10.18%**

Clarksons Research

Important note:

- Scrubber equipped fleet **(if and when materialized)** will include 22% of Capesize+, 33% of VLCCs, 50% of ULCS and 41% of VLCS
- In terms of HFO consumption the percentage for the scrubber equipped vessels **(if and when materialized)** will be much more than the apparent 10% which is their percentage in terms of vessel number
- **If and when the ordered units are retrofitted,** the Scrubbers will play an important part in ensuring sufficient global refining capacity to meet demand for the 0.50% sulphur limit in 2020 as it allows a portion of the global fleet to continue using high sulphur fuel oil, thereby easing some of the demand pressure on low sulphur fuels

BUREAU VERITAS

LATEST REGULATORY DEVELOPMENTS

Revision of IMO 2015 EGCS Guidelines:

- Under progress – Expected within 2019, to be delayed to within 2020.
- Issues to be addressed:
  - Redundancy
  - Contingency measures (Use of compliant fuel?) –> Addressed in MEPC 74
  - Testing, Survey and certification
  - Wash water effluent standards ? – To be addressed in PPR7

Local port authorities prohibitions of open loop scrubbers:

- Currently from Singapore, China, Belgium, Germany, Baltic countries, Connecticut and California.
- Ocean going vessels will not be significantly affected as pay back periods are usually calculated without port use of the scrubber
- Could be very important for coastal shipping and for vessels spending considerable time in ports

Several studies on environmental effects of scrubber effluents, with conflicting results

BUREAU VERITAS

STATUS / RESULTS OF CURRENT STUDIES

- **Panama backed study by MIT:** -> “Cause for concern about pollutants contained in scrubber discharges”
- **German study:** -> “Scrubbers are new direct pollution source to marine environment”
- **Denmark Study:** -> “Concentration of pollutants in the sea will be orders of magnitude below the levels of concern as expressed e.g. by EU's environmental quality standards (EQS) for the marine environment.”
- **Japan administration study:** -> “Open-loop scrubbers “cannot” have short or long-term effects on marine organisms”.
- **Carnival – SGS – DNV-GL study:** -> “Effluents meet several land based point source waste water standards and even WHO drinking water guidelines for heavy metals concentration”
- **Independent IMO study?** -> ? MEPC 74 approved, in principle, a new output on "Evaluation and harmonization of rules and guidance on the discharge of liquid effluents from EGCS into waters, including conditions and areas" in the 2020-2021 biennial agenda of the PPR and the provisional agenda for PPR 7, with a target completion year of 2021. GESAMP could establish a task team to assess the available evidence relating to the environmental impact of discharges of exhaust gas cleaning system effluent. Appropriate experts would have to be identified and sufficient external funding would have to be secured.
- **GESAMP advice:** The environmental benefits of reducing pollution to air not to be diminished in the event that EGCS discharge washwater presented additional risks.

MLIT Ministry of Land, Infrastructure and Transport

CARNIVAL CORPORATION&PLC

Danish Ministry of the Environment
Environmental Protection Agency

IMO

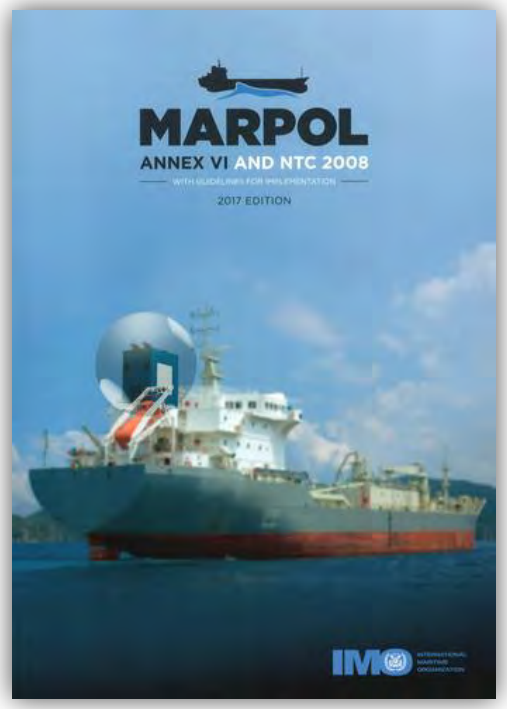
BUREAU VERITAS

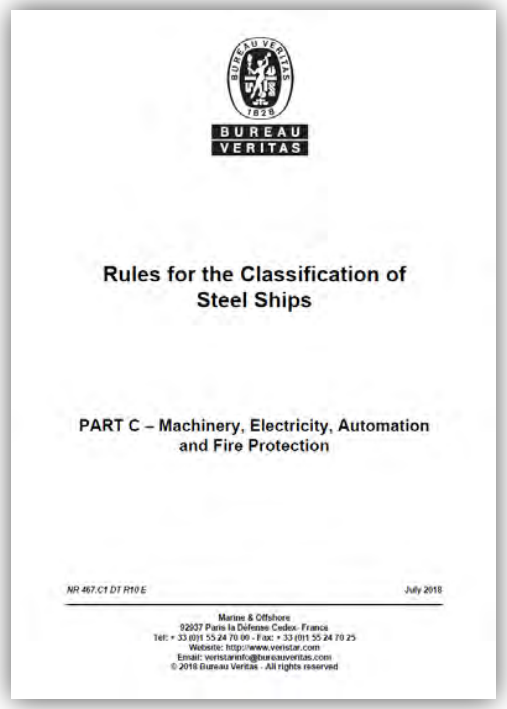
LIMITATIONS OF CURRENT STUDIES

- Many not based on systematic sampling
- Some only based on literature review
- For studies based on sampling, samples were taken either from one ship (e.g. Denmark study with one ro-ro ferry) or for one type of vessel/engine and scrubber (Carnival, cruise ships, 4-stroke, Ecospray scrubber)

SCRUBBER CERTIFICATION

- Statutory Certification
- Classification Aspect Design Review





STATUTORY CERTIFICATION - MARPOL

MEPC .259(68) includes two schemes of certification:

Scheme A: Unit certification with in-service parameter and emission checks.

Under 'Scheme A', the scrubber is formally tested to assess its operational behavior, approved and certified before being put into service. -> Similar to a type approval process

Main difficulty: Tests need to be done on an engine installation, difficult to be performed on shore facility. If performed on board, then certification would be valid only on identical installations on identical vessels/engines

Scheme B: Continuous emission monitoring with parameter checks.

Under "Scheme B" sophisticated emissions monitoring equipment for exhaust gas and wash water are used on a continuous basis. Certification is installation/ship specific.

Note: *Under EU and other port authorities regulations, continuous monitoring and recording of EGCS performance is required so Scheme B is the preferred choice also for this reason.*

BUREAU VERITAS

STATUTORY CERTIFICATION - MED

In the case of EU flagged vessels MED certification is applicable, as Exhaust Gas Cleaning Systems. The following documents need to be submitted for review related to Marine Equipment Directive (MED 2014/90 EU):

- Description of the scrubber and its associated equipment
- General arrangement
- P&ID of the scrubber installation
- List of equipment
- Maintenance manual
- Brochure of the Continuous Emission Monitoring System (CEMS)
- Water monitoring unit (TPP) P&ID and details
- Standard(s) of the manufacturing of scrubber tower and its fittings
- Drawing details of scrubber tower with design pressure and temperature, material specification (work certificate (3.1))(type, thickness ..)
- Drawings and material specification of nozzles and fittings
- Welding details, including at least: type weld joint design, welding procedure specifications and post-weld treatment
- Corrosion factor for the calculation of the required minimum design thickness
- Risk analysis: Availability of the machinery served by the exhaust gas treatment system is to be substantiated by a risk analysis and the use of chemical products (for a each specific ship installation project)

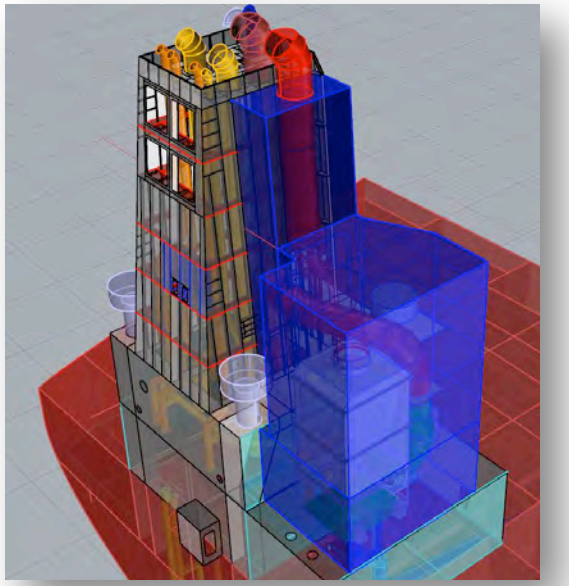
STATUTORY CERTIFICATION – IMPORTANT POINTS

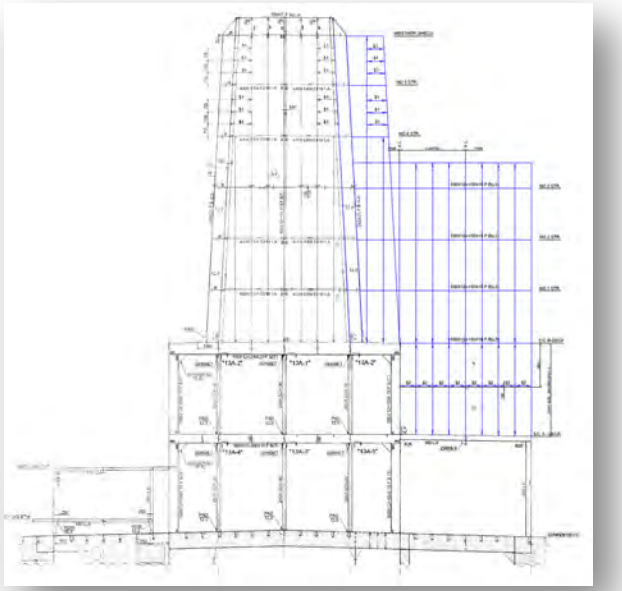
- Manufacturer has to contact Class as early as possible with all info necessary to complete the statutory certification
- MARPOL Certification for Scheme B is ship specific so documents have to be submitted for each vessel separately, even for sister ships
- Good project planning and document control is extremely important to avoid delays
- Owners: Check that manufacturer has previous experience in completing a Scheme B certification process with an IACS society – Manufacturers with previous experience in certifying marine equipment may be better choice but not necessarily

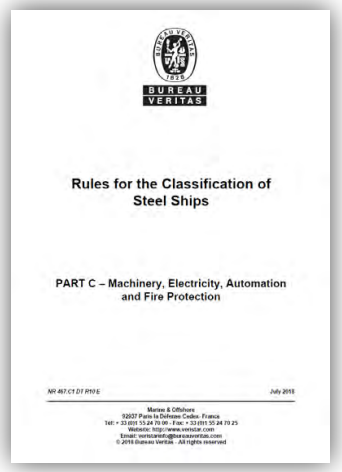
CLASSIFICATION DESIGN REVIEW

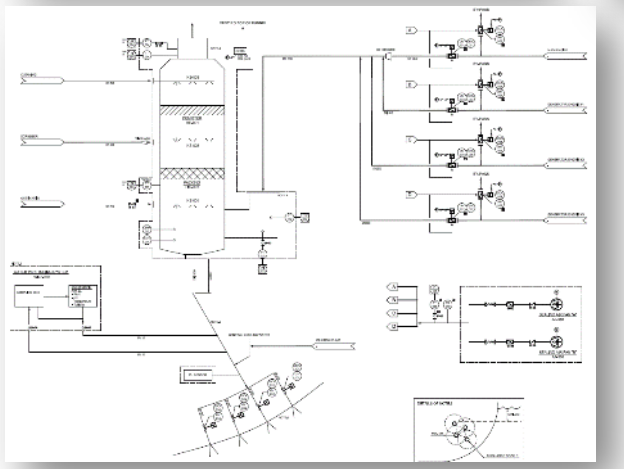
Following disciplines are involved:

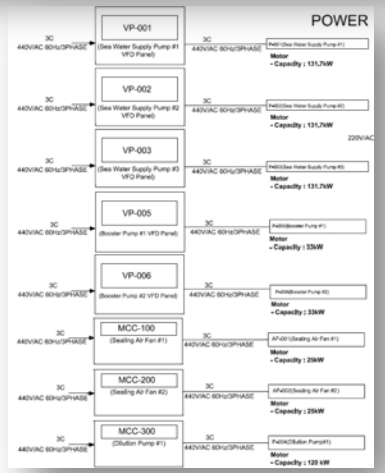
- Hull structure
- Machinery / Fire safety
- Electrical & Automation
- Stability
- Others (e.g. Tonnage)







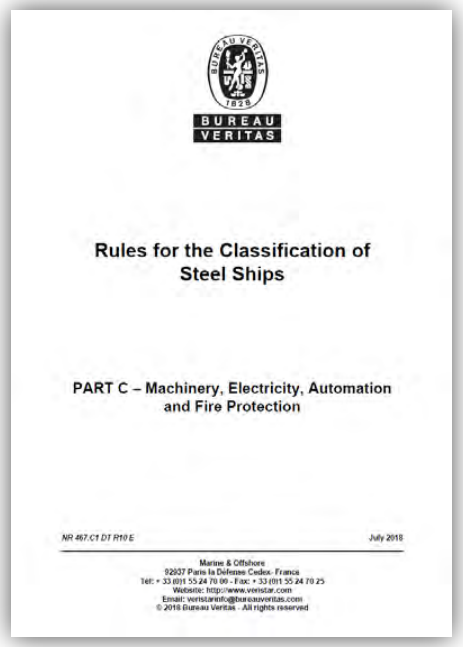




CLASSIFICATION DESIGN REVIEW

Important issues to be correctly defined at an early stage:

- Bypass arrangements and isolation of EG pipes
- Housing of scrubber (connected to E/R or not – Fire Safety)
- Back pressure
- Wash water pipe material
- Sea chest arrangement – connection to existing cross over
- Need for dilution/reaction water (VGP compliance)
- Ship side valves construction and control
- Risk assessment – Availability of ship's essential equipment is ensured if any of the EGCS systems fail

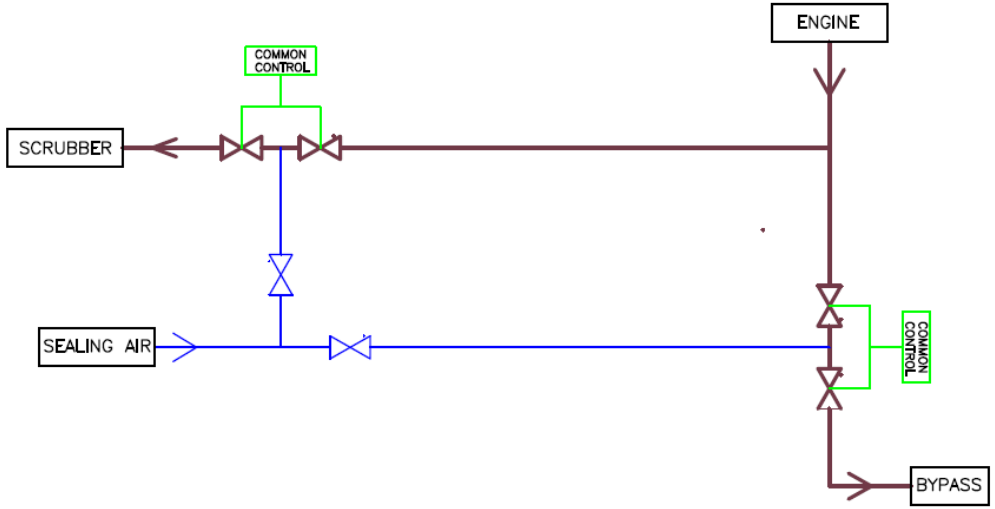


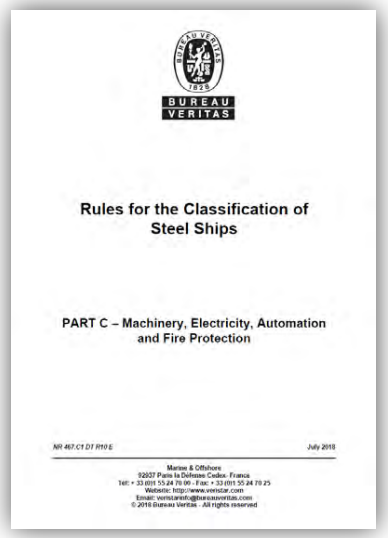
CLASSIFICATION DESIGN REVIEW

Issues to be dealt with for bypass arrangements and isolation of EG pipes

- Prevention of backflow of exhaust gases
- For engines provided with a bypass protection of personnel performing scrubber maintenance should be considered

For both above issues isolation valves with use of sealing air are the best solution.

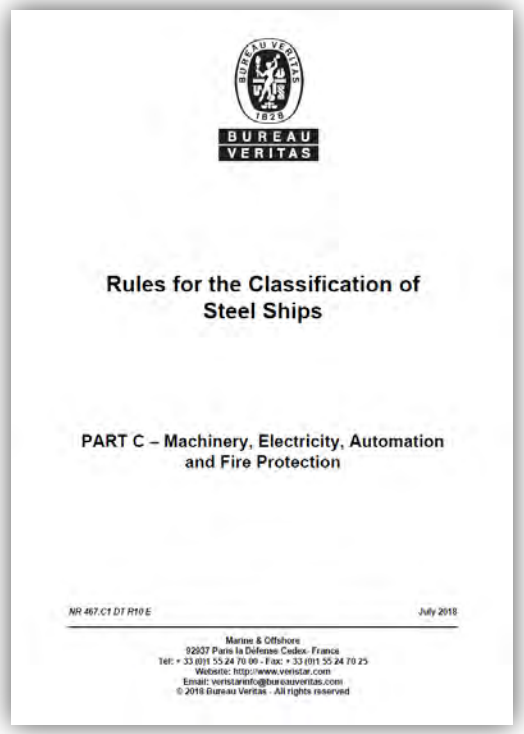




CLASSIFICATION DESIGN REVIEW

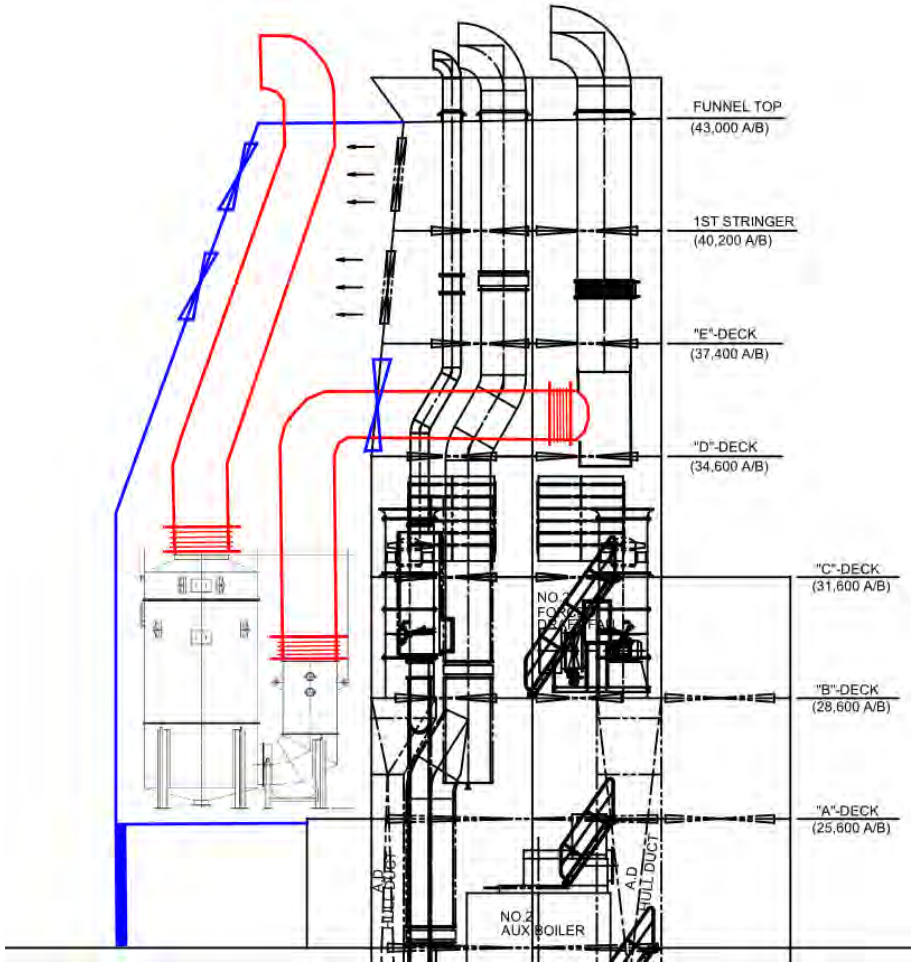
Housing of scrubber in case of bypass of M/E:

- Option 1: Housing connected to ER space:
- Option 2: Housing separate from ER space but with common Bhd.
- Option 3: Housing separate from ER space but without common bulkhead.



CLASSIFICATION DESIGN REVIEW

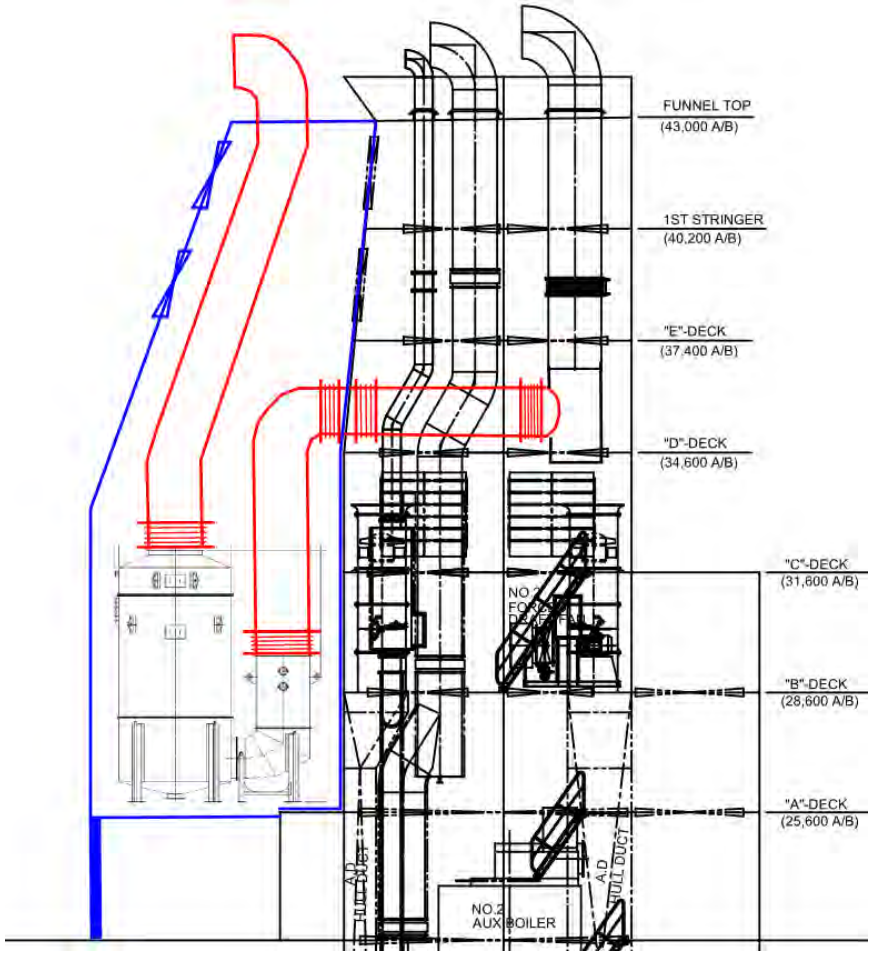
- Option 1: Housing connected to ER space:



- Categorized as Machinery space of category A / Space Cat.6
- Two means of escape to be arranged
- Ventilation ducts from E/R to be routed into this space
- Existing firefighting systems must be able to cover additional volume
- At least one hydrant and hose to be provided
- At least two portable FFE to be provided (One CO_2 and one for Class B fires)

CLASSIFICATION DESIGN REVIEW

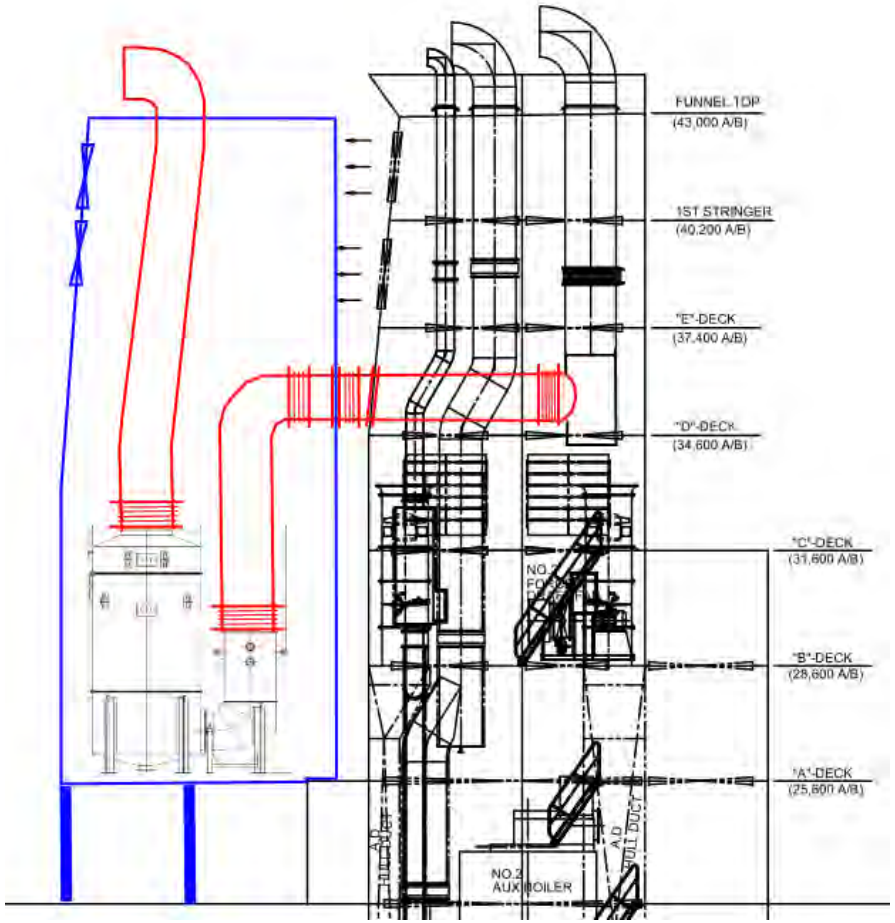
- Option 2: Housing separate from ER space but with common Bhd.



- Categorized as Other Machinery space / Space Cat.7
- Pipe penetrations to be gastight and A0 Class standard
- Additional compensators will be required for EG pipes
- Independent ventilation must be arranged (may be natural ventilation
- If travel distance to the door is more than 5m, two means of escape to be arranged
- Appropriate insulation to be arranged with adjacent spaces (if any)
- At least one portable FFE to be provided for fires Cat. B or C near the exit/entrance. Additional CO2 FE if electrical equipment are also housed.

CLASSIFICATION DESIGN REVIEW

- Option 3: Housing separate from ER space but without common bulkhead.



- Categorized as Other Machinery space / Space Cat.7
- No need for gas tight or A0 pipe penetrations
- Additional compensators will be required for EG pipes
- Independent ventilation must be arranged (may be natural ventilation
- If travel distance to the door is more than 5m, two means of escape to be arranged
- Appropriate insulation to be arranged with adjacent spaces (if any)
- At least one portable FFE to be provided for fires Cat. B or C near the exit/entrance. Additional CO2 FE if electrical equipment are also housed.

CLASSIFICATION DESIGN REVIEW

Back Pressure: Options when back pressure from scrubber is exceeding T/C normal operation limits:

1. Addition of exhaust gas fan (forced ventilation)

2. Re-matching of T/C with the new back pressure

- 2.1 If NOx TF is not affected, documentation from engine / TC manufacturer to be submitted for review

- 2.2 If NOx TF is affected, revision of the TF and full range of tests to be performed

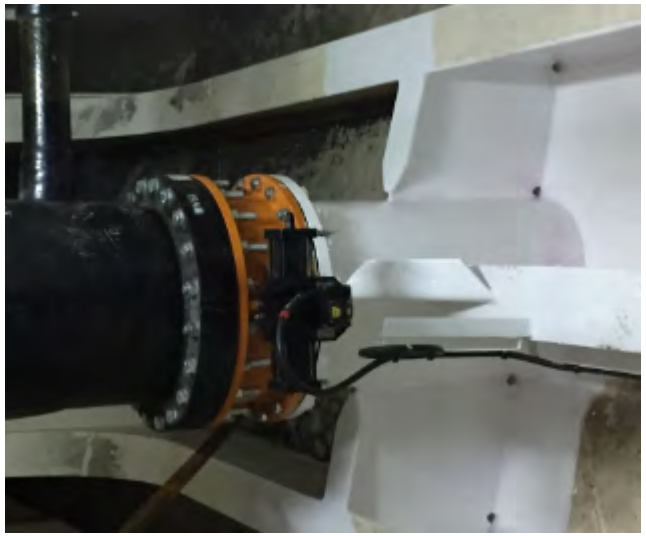
Note: On going discussion at the moment between BV and ABB about re-matching T/C without affecting the NOx Technical File.

CLASSIFICATION DESIGN REVIEW

Issues to be dealt with for Ship Side valves:

- According to IACS UR P4/A.753(18)/MSC.313(88): For composite sea water pipes in engine room, ship side valves are to be able to be controlled remotely from a space outside the engine room. This is not connected to flooding but to fire hazard.

- Alternative arrangements should be appropriately substantiated and specially considered and flag acceptance obtained.



CLASSIFICATION DESIGN REVIEW

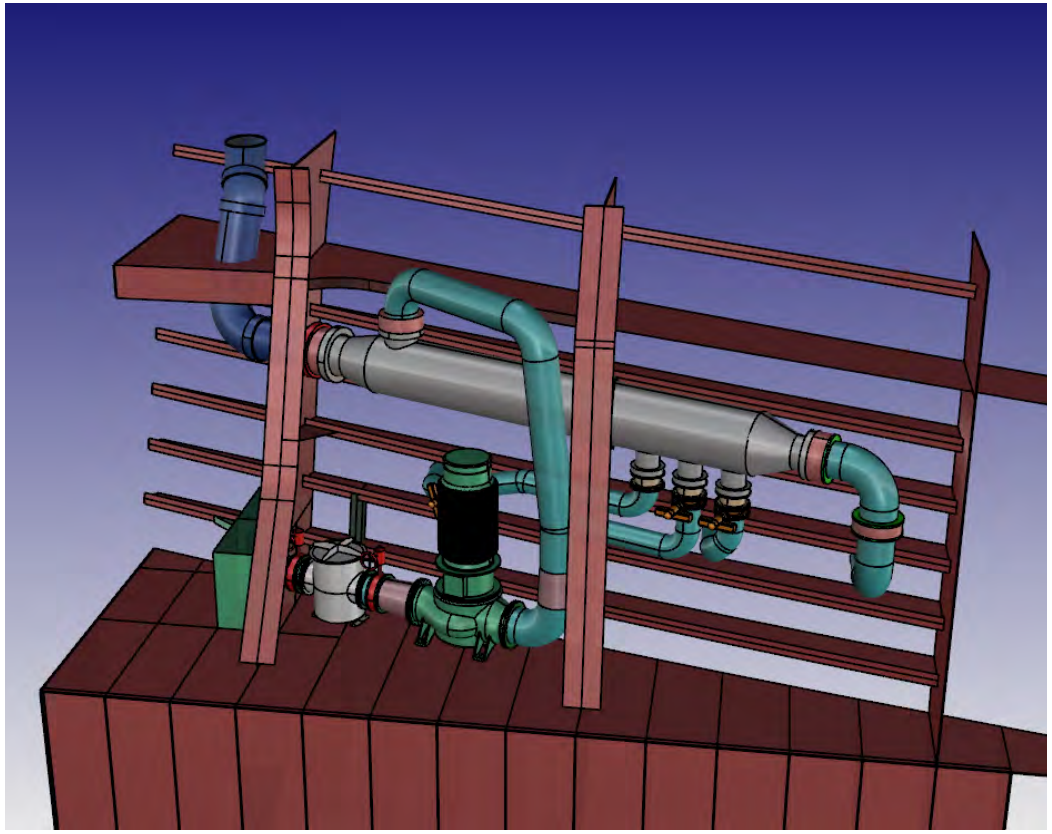
Connection to existing cross over lines:

- Flow velocity must be within acceptable limits
- If GRE water inlet pipes are used, isolation valve is proposed to also be remotely controlled outside the engine room space (to avoid flooding of engine room if GRE pipes are damaged by fire)

CLASSIFICATION DESIGN REVIEW

Need for dilution/reaction water:

- Check with manufacturer if it is needed only for VGP compliance.
- Any use of mixing orifice or mixing devices must be documented and reflected in the CFD analysis and the statutory documents.
- Reaction/dilution water may be either from sea chest or from cooling water piping. Flow velocity must be checked. If both options are utilized automation software must handle the flow to avoid lack of cooling water in the main consumers. Risk assessment must cover this.
- Increased diameter of piping after mixing often needs custom GRE fittings and sensitive structural penetrations

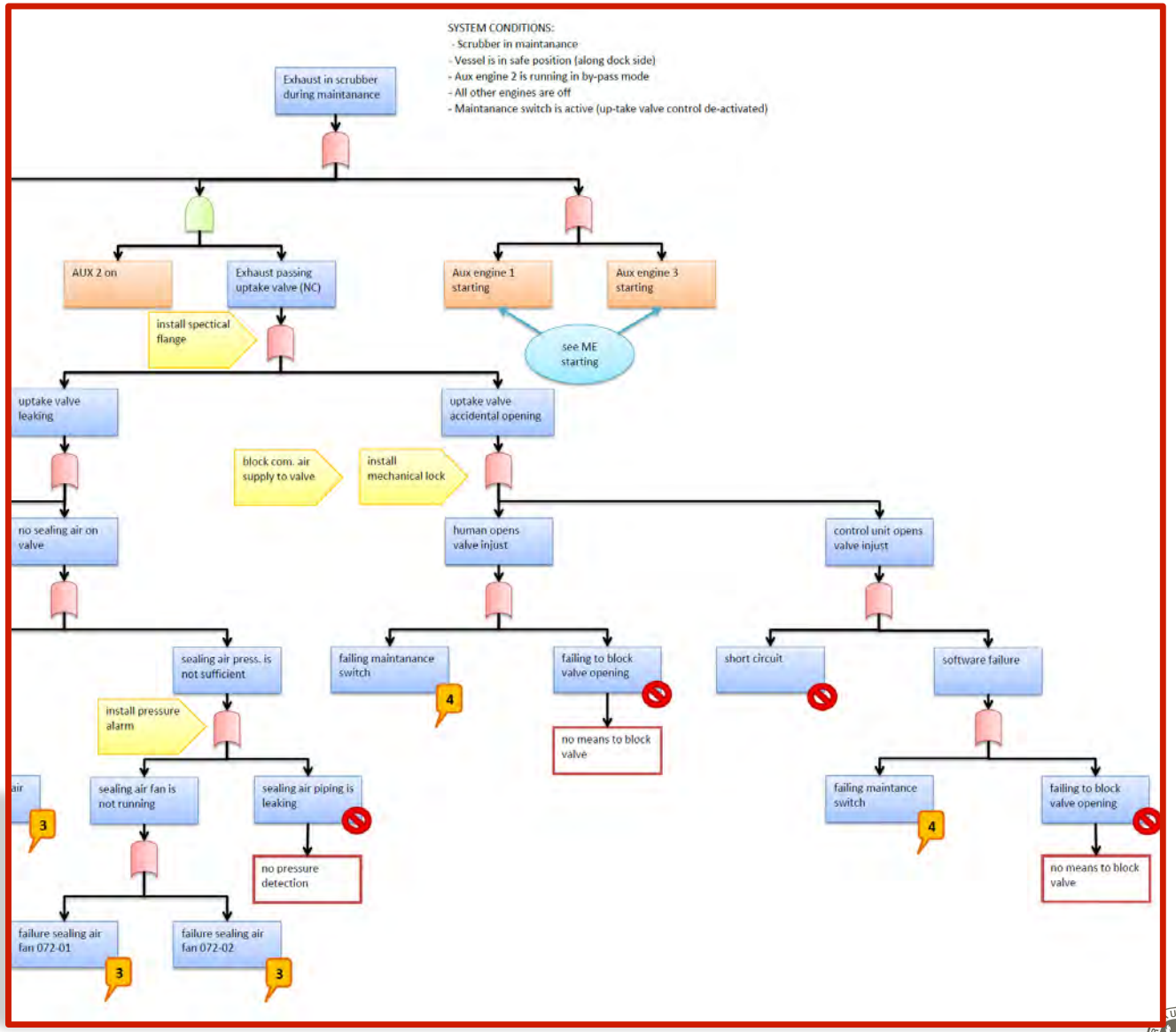


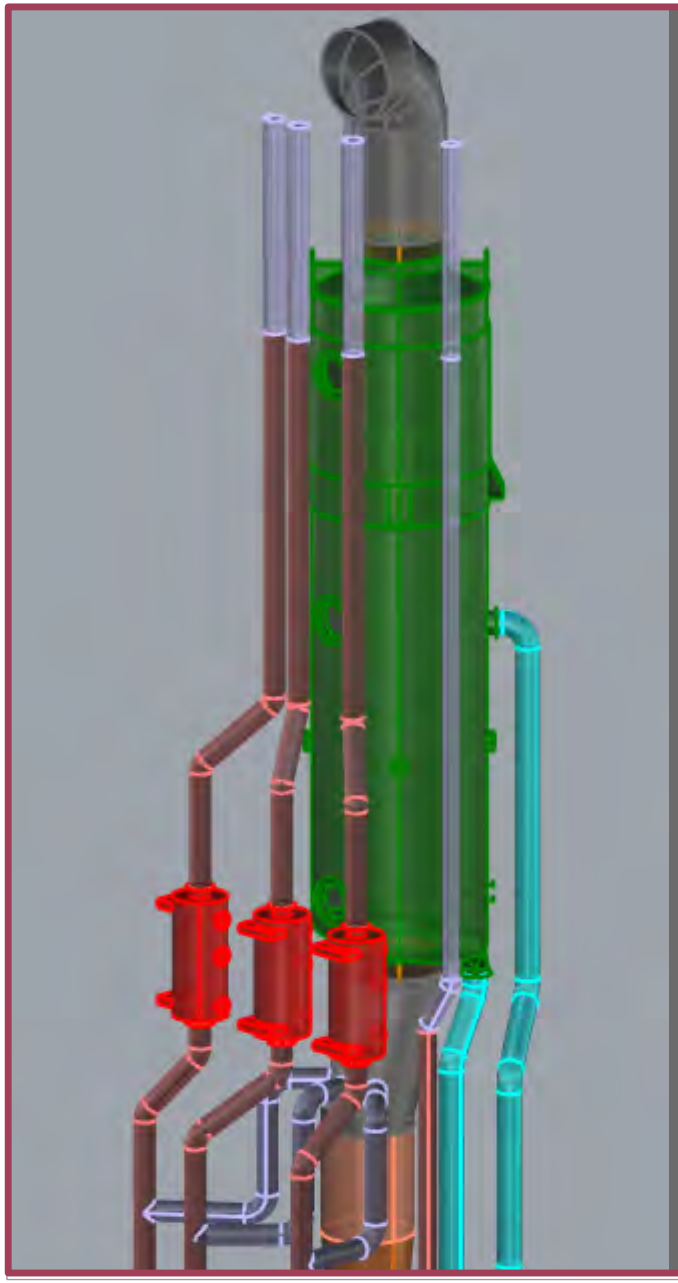
CLASSIFICATION DESIGN REVIEW

Risk assessment:

BV Rules Pt C, Ch 1, Sec 10, Par 18.5.3:
“Availability of the machinery served by the exhaust gas treatment system is to be substantiated by a risk analysis. The exhaust gas treatment equipment is to be so arranged that, in the case of failure of such equipment, propulsion power and auxiliary power supplying essential functions are not affected.”

FMEA (Failure Mode Effect Analysis) is the most efficient method to be used however other methodologies (e.g. Fault tree analysis) may be accepted.





Thank you