Graduated Coating and Surface Preparation QA/QC Processes

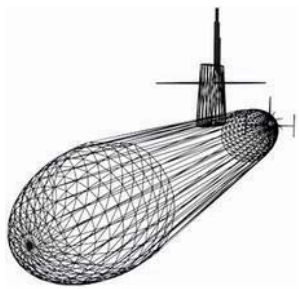
Project Update

NSRP SP-3 Panel Meeting

July 19-20, 2007

Elzly Technology Corporation

TODD PACIFIC SHIPYARDS

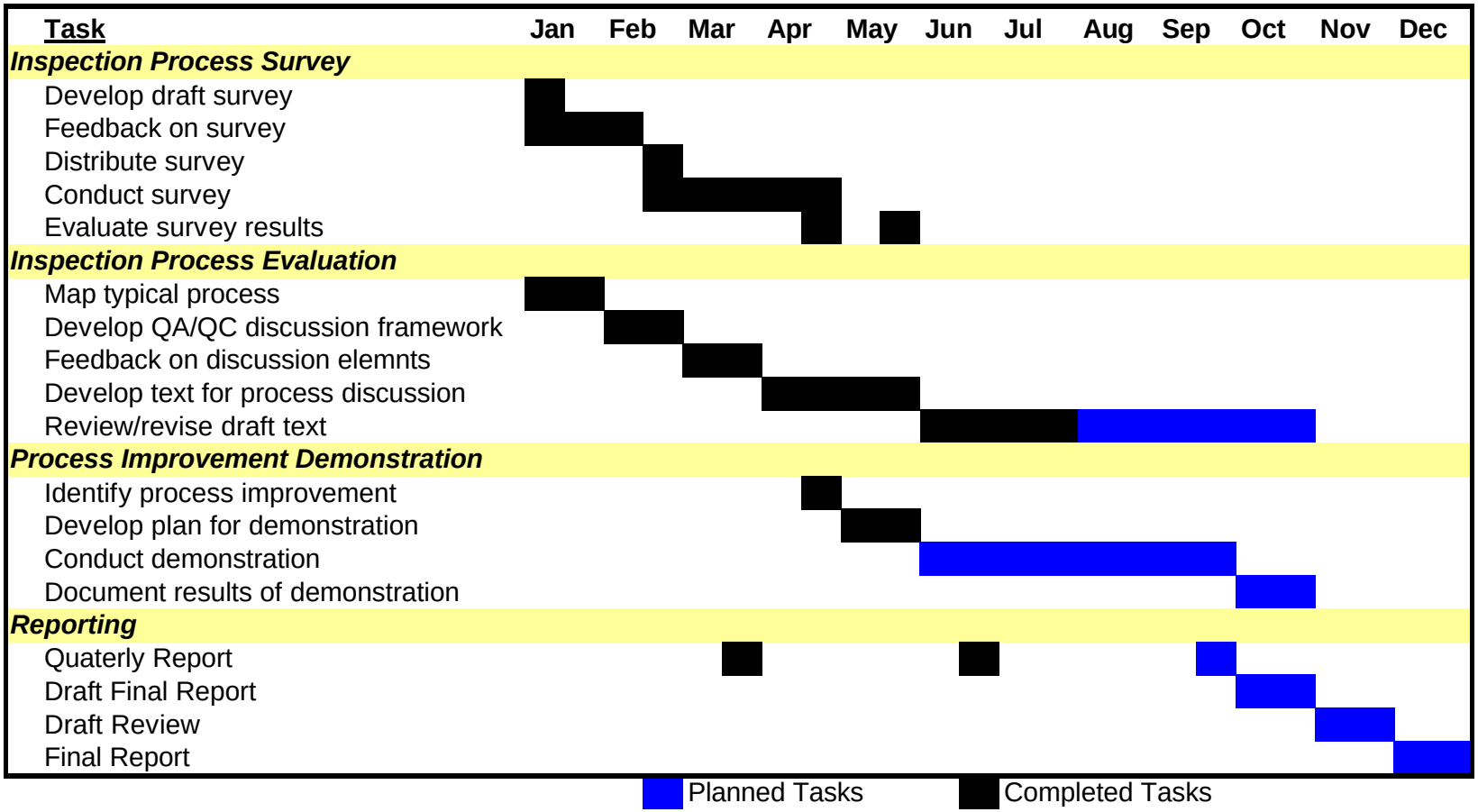


Corrosion Correctors LLC

Project Goal

- Improve Coating Inspection Process
  - Produce a guidance document which identifies/demonstrates technologies and processes which may reduce the cost of QA/QC without impacting the quality of workmanship or the risk associated with achieving that quality

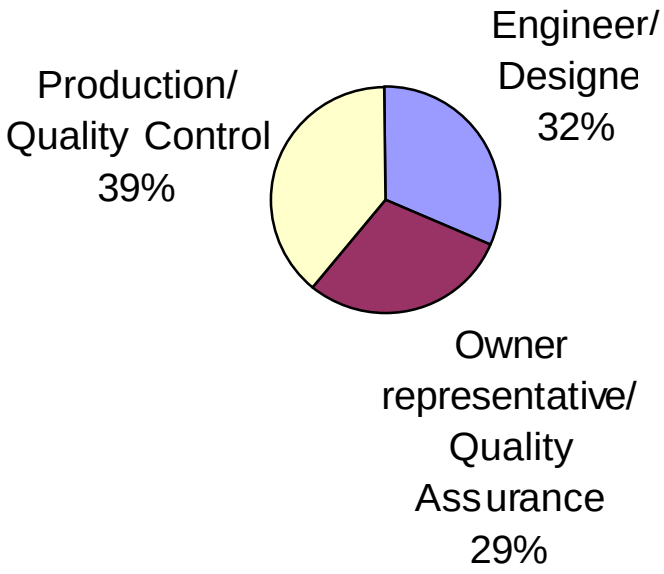
Project Schedule

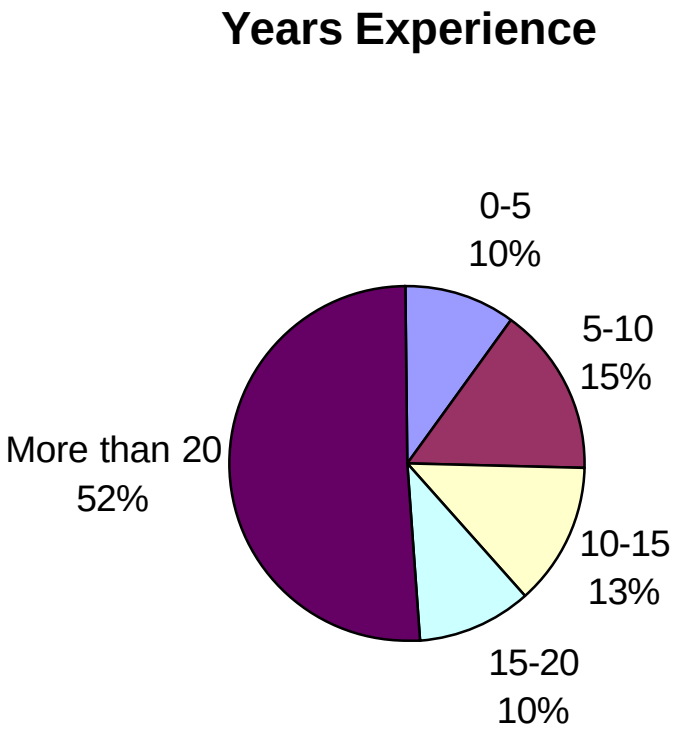


QA/QC Inspection Process Survey

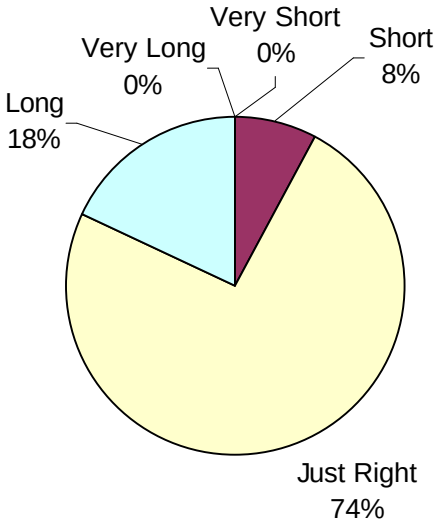
- Purpose – to determine popular opinion
  - What non-conformities
    - Are most likely to occur
    - Have the greatest impact on coating life
    - Are most expensive to repair
  - What inspection processes are
    - Most expensive
    - Most ambiguous
    - Least effective

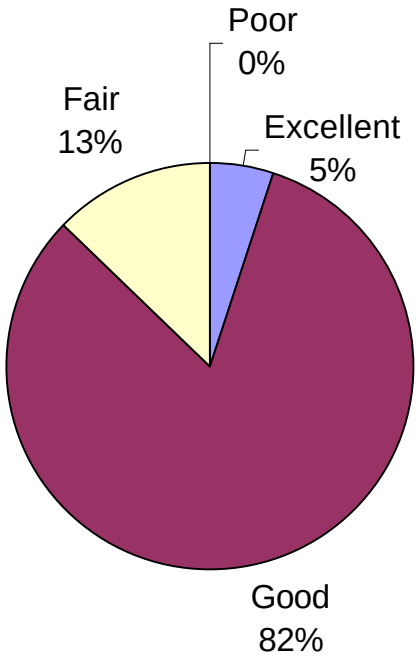
Demographics – 58 Respondents

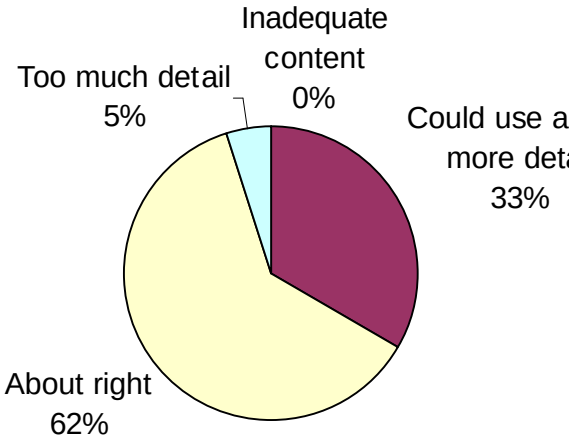




Survey Evaluation







Likelihood of Non-Conformities

Likelihood	Certain	1 in 2	1 in 5	1 in 10	1 in 20	1 in 100	Unlikely
Visible surface contamination (e.g. dust)	30%	32%	20%	5%	7%	4%	2%
Invisible surface contamination (e.g. salts)	38%	17%	19%	19%	0%	8%	0%
Steel surface irregularities (weld splater rough edges etc)	36%	25%	15%	9%	8%	8%	0%
Holidays or bare areas (individual coat)	27%	23%	6%	12%	23%	4%	6%
Insufficient film thickness (individual coat)	10%	21%	25%	23%	10%	8%	4%
Excessive film thickness (individual coat)	6%	19%	29%	15%	19%	12%	0%
Flash Rusting	10%	15%	23%	23%	17%	10%	2%
Improper environmental conditions	10%	21%	21%	15%	15%	13%	4%
Excessive film thickness (complete system)	8%	13%	13%	19%	27%	19%	0%
Excessive surface profile	8%	15%	17%	15%	11%	30%	4%
Insufficient film thickness (complete system)	4%	12%	17%	19%	27%	17%	4%
Holidays or bare areas (entire system)	16%	6%	8%	10%	25%	24%	12%
Insufficient surface profile	4%	4%	19%	26%	13%	28%	6%
Missing stripe coat	4%	8%	12%	20%	14%	27%	16%
Poor coating adhesion	8%	4%	6%	12%	25%	41%	4%
Improperly cured coating	6%	2%	8%	17%	19%	42%	6%

Non-Conformity Impact

Impact on Life	Negligible	5% Reduction	10% Reduction	25% Reduction	50% Reduction	Catastrophic
Poor coating adhesion	4%	0%	16%	12%	25%	43%
Improperly cured coating	8%	2%	10%	10%	27%	44%
Invisible surface contamination (e.g. salts)	8%	6%	12%	23%	29%	23%
Holidays or bare areas (entire system)	6%	10%	16%	22%	24%	24%
Insufficient film thickness (complete system)	10%	15%	13%	27%	33%	2%
Insufficient surface profile	14%	14%	16%	24%	22%	12%
Improper environmental conditions	19%	12%	15%	19%	19%	15%
Holidays or bare areas (individual coat)	8%	24%	20%	18%	20%	12%
Missing stripe coat	8%	16%	25%	31%	18%	2%
Steel surface irregularities (weld splater rough edges etc)	10%	25%	18%	29%	18%	0%
Insufficient film thickness (individual coat)	19%	15%	21%	21%	17%	6%
Visible surface contamination (e.g. dust)	19%	22%	19%	19%	13%	9%
Flash Rusting	25%	25%	15%	15%	17%	2%
Excessive surface profile	48%	13%	12%	8%	13%	6%
Excessive film thickness (complete system)	35%	27%	13%	15%	6%	4%
Excessive film thickness (individual coat)	38%	23%	19%	15%	2%	2%

Cost to Repair Non-Conformity

Cost to Repair	Negligible	2	3	Acceptable	5	6	Prohibitive
Poor coating adhesion	6%	0%	4%	26%	6%	24%	34%
Improperly cured coating	10%	4%	0%	28%	14%	20%	24%
Excessive film thickness (complete system)	16%	4%	6%	25%	12%	14%	24%
Invisible surface contamination (e.g. salts)	8%	4%	6%	45%	16%	4%	18%
Insufficient surface profile	10%	6%	4%	43%	10%	12%	16%
Steel surface irregularities (weld splater rough edges etc)	8%	6%	10%	42%	8%	10%	16%
Excessive surface profile	24%	4%	0%	24%	10%	10%	27%
Excessive film thickness (individual coat)	12%	6%	8%	33%	18%	6%	18%
Improper environmental conditions	16%	4%	8%	34%	10%	10%	18%
Holidays or bare areas (entire system)	10%	10%	2%	46%	12%	4%	16%
Missing stripe coat	12%	6%	8%	46%	12%	2%	14%
Insufficient film thickness (complete system)	14%	4%	6%	47%	12%	8%	10%
Flash Rusting	14%	10%	4%	49%	18%	0%	6%
Insufficient film thickness (individual coat)	16%	10%	6%	47%	10%	6%	6%
Holidays or bare areas (individual coat)	18%	14%	10%	42%	10%	2%	4%
Visible surface contamination (e.g. dust)	42%	9%	9%	27%	5%	0%	7%

Ranking of Concern over Non-Conformities

Non-Conformities	1 to 10		Liklihoo	Impact	Cost
Invisible surface contamination (e.g. salts)	6.58		7.52	6.58	5.65
Poor coating adhesion	6.18		3.63	7.69	7.23
Improperly cured coating	5.84		3.46	7.58	6.47
Steel surface irregularities (weld splater rough edges etc)	5.79		7.48	4.39	5.50
Improper environmental conditions	5.35		5.64	5.08	5.33
Holidays or bare areas (entire system)	5.31		4.31	6.35	5.27
Holidays or bare areas (individual coat)	5.12		6.41	5.06	3.90
Insufficient surface profile	5.00		4.18	5.22	5.59
Insufficient film thickness (complete system)	4.98		4.65	5.27	5.03
Insufficient film thickness (individual coat)	4.94		5.99	4.38	4.44
Visible surface contamination (e.g. dust)	4.92		7.59	4.26	2.91
Flash Rusting	4.60		5.67	3.62	4.51
Excessive film thickness (individual coat)	4.55		5.71	2.50	5.46
Excessive film thickness (complete system)	4.54		4.97	2.85	5.82
Missing stripe coat	4.53		3.73	4.82	5.03
Excessive surface profile	4.37		4.78	2.85	5.48

Increasing Concern >>>>

Inspection Process Cost

Inspection Process Cost	Negligible	2	3	Reasonable	5	6	Prohibitive
Electrical Holiday Detection	2%	0%	2%	31%	24%	21%	19%
Laboratory QA of Coating Material	4%	0%	2%	33%	22%	24%	15%
Continuous Environmental Monitoring	2%	2%	11%	35%	17%	20%	13%
Surface Salts (Conductivity Measurement)	2%	5%	0%	58%	16%	9%	9%
Recordkeeping (report to owner)	0%	2%	4%	64%	16%	7%	7%
Surface Salts (Chloride Measurement)	5%	2%	2%	57%	20%	7%	7%
Containment Integrity	5%	5%	12%	53%	14%	5%	7%
Field check of coating properties (e.g. viscosity)	9%	5%	9%	53%	7%	9%	7%
Anchor Profile (Testex Tape)	18%	2%	4%	56%	9%	2%	9%
Visual Surface Irregularities (weld splatter edge prep etc)	9%	14%	0%	64%	7%	0%	7%
Environmental Conditions during cure	16%	7%	11%	47%	7%	4%	9%
UV Surface Cleanliness (oil grease etc)	11%	7%	7%	59%	11%	2%	2%
Environmental Conditions Monitoring	13%	9%	2%	64%	4%	2%	4%
Anchor Profile (Dial Depth Gauge)	17%	5%	12%	45%	14%	2%	5%
Dry Film Thickness (SSPC PA-2) – Intermediate Coats	16%	2%	9%	59%	7%	7%	0%
Dust (Tape Test)	19%	5%	10%	50%	7%	5%	5%
Dry Film Thickness (SSPC PA-2) – System	16%	5%	7%	61%	7%	2%	2%
Dry Film Thickness (SSPC PA-2) – Primer	18%	2%	9%	61%	7%	2%	0%
Anchor Profile (Comparator)	19%	10%	7%	50%	7%	2%	5%
Environmental Conditions during coating application	18%	11%	4%	58%	2%	0%	7%
Degree of Flash Rusting	20%	14%	9%	50%	2%	0%	5%
Visual Holiday Detection – System	20%	14%	14%	43%	2%	2%	5%
Visual Holiday Detection – Primer	25%	11%	14%	39%	0%	7%	5%
Visual Holiday Detection – Intermediate Coats	27%	11%	9%	41%	0%	5%	7%
Substrate Surface Temperature	36%	5%	7%	48%	0%	0%	5%
Wet Film Thickness	34%	16%	9%	36%	2%	0%	2%
Visual Surface Cleanliness	36%	11%	7%	47%	0%	0%	0%
Dust (Visual)	45%	11%	11%	27%	0%	2%	2%

Disputes Over Inspection Results

Dispute Likelihood	Never	Infrequent	1 in 100	1 in 20	1 in 5	Half	Always
Degree of Flash Rusting	2%	16%	9%	27%	18%	20%	7%
Visual Surface Cleanliness	0%	31%	16%	16%	27%	11%	0%
Visual Surface Irregularities (weld splatter edge prep etc)	2%	39%	2%	30%	14%	11%	2%
UV Surface Cleanliness (oil grease etc)	5%	26%	21%	21%	23%	2%	2%
Surface Salts (Conductivity Measurement)	9%	33%	7%	21%	14%	14%	2%
Anchor Profile (Comparator)	7%	39%	7%	15%	20%	10%	2%
Dry Film Thickness (SSPC PA-2) – System	5%	41%	7%	20%	16%	11%	0%
Dry Film Thickness (SSPC PA-2) – Primer	5%	41%	7%	25%	11%	11%	0%
Dry Film Thickness (SSPC PA-2) – Intermediate Coats	5%	41%	9%	20%	14%	11%	0%
Surface Salts (Chloride Measurement)	11%	32%	7%	25%	16%	9%	0%
Dust (Tape Test)	7%	38%	19%	12%	10%	10%	5%
Dust (Visual)	7%	40%	14%	16%	9%	12%	2%
Visual Holiday Detection – Intermediate Coats	7%	43%	11%	16%	14%	9%	0%
Anchor Profile (Dial Depth Gauge)	7%	45%	7%	17%	17%	7%	0%
Visual Holiday Detection – Primer	9%	39%	16%	14%	14%	9%	0%
Visual Holiday Detection – System	7%	43%	14%	14%	16%	7%	0%
Recordkeeping (report to owner)	9%	38%	18%	16%	13%	7%	0%
Field check of coating properties (e.g. viscosity)	12%	35%	21%	16%	7%	7%	2%
Environmental Conditions Monitoring	9%	42%	13%	16%	18%	2%	0%
Environmental Conditions during coating application	14%	34%	18%	14%	18%	2%	0%
Environmental Conditions during cure	9%	43%	11%	18%	16%	2%	0%
Continuous Environmental Monitoring	9%	50%	11%	9%	13%	9%	0%
Anchor Profile (Testex Tape)	13%	47%	7%	13%	9%	9%	2%
Containment Integrity	7%	49%	9%	26%	5%	5%	0%
Electrical Holiday Detection	10%	52%	12%	12%	5%	7%	2%
Substrate Surface Temperature	7%	57%	11%	9%	11%	2%	2%
Laboratory QA of Coating Material	17%	43%	9%	13%	13%	4%	0%
Wet Film Thickness	7%	61%	14%	7%	2%	5%	5%

Effectiveness of Inspection

Effectiveness	Rarely Detects	Detects 25%	Detects 50%	Detects 75%	Detects 90%	Always Detects
Field check of coating properties (e.g. viscosity)	26%	21%	19%	12%	12%	10%
Visual Holiday Detection – Intermediate Coats	9%	16%	30%	16%	23%	5%
Visual Holiday Detection – System	9%	19%	21%	19%	26%	7%
Anchor Profile (Comparator)	7%	12%	34%	17%	17%	12%
Visual Holiday Detection – Primer	9%	12%	23%	23%	28%	5%
Anchor Profile (Dial Depth Gauge)	7%	17%	17%	17%	24%	17%
Visual Surface Irregularities (weld splatter edge prep etc)	9%	14%	11%	20%	36%	9%
Visual Surface Cleanliness	2%	16%	22%	22%	24%	13%
UV Surface Cleanliness (oil grease etc)	7%	10%	21%	24%	21%	17%
Wet Film Thickness	9%	9%	19%	16%	33%	14%
Dust (Visual)	7%	5%	30%	14%	30%	14%
Containment Integrity	7%	9%	14%	21%	42%	7%
Degree of Flash Rusting	2%	11%	20%	23%	30%	14%
Recordkeeping (report to owner)	13%	2%	13%	13%	40%	18%
Surface Salts (Chloride Measurement)	5%	14%	12%	19%	28%	23%
Surface Salts (Conductivity Measurement)	5%	17%	7%	17%	31%	24%
Dry Film Thickness (SSPC PA-2) – Intermediate Coats	7%	5%	9%	23%	43%	14%
Continuous Environmental Monitoring	11%	4%	11%	11%	41%	22%
Environmental Conditions during cure	7%	7%	18%	7%	36%	25%
Dry Film Thickness (SSPC PA-2) – Primer	7%	5%	9%	18%	48%	14%
Electrical Holiday Detection	7%	5%	7%	19%	45%	17%
Environmental Conditions during coating application	7%	7%	11%	11%	41%	23%
Dry Film Thickness (SSPC PA-2) – System	5%	0%	9%	32%	41%	14%
Laboratory QA of Coating Material	7%	4%	17%	9%	33%	30%
Dust (Tape Test)	5%	2%	14%	21%	29%	29%
Substrate Surface Temperature	7%	5%	14%	5%	43%	27%
Environmental Conditions Monitoring	11%	7%	7%	7%	27%	42%
Anchor Profile (Testex Tape)	2%	9%	9%	9%	34%	36%

Ranking of Inspection Processes

Inspection Processes	1 to 10		Cost	Dispute	Effectiveness
Field check of coating properties (e.g. viscosity)	5.52		5.00	3.37	8.19
Surface Salts (Conductivity Measurement)	5.15		5.78	4.15	5.52
Electrical Holiday Detection	5.04		6.90	3.02	5.19
Visual Surface Irregularities (weld splatter edge prep etc)	5.02		4.55	4.28	6.23
Degree of Flash Rusting	5.01		3.64	5.53	5.86
Surface Salts (Chloride Measurement)	4.99		5.57	3.83	5.58
Anchor Profile (Comparator)	4.94		4.05	3.98	6.78
Continuous Environmental Monitoring	4.93		6.23	3.22	5.35
UV Surface Cleanliness (oil grease etc)	4.92		4.47	4.15	6.14
Recordkeeping (report to owner)	4.92		5.67	3.44	5.64
Laboratory QA of Coating Material	4.87		6.67	2.90	5.04
Visual Holiday Detection – Intermediate Coats	4.77		3.60	3.56	7.16
Containment Integrity	4.74		5.16	3.10	5.95
Anchor Profile (Dial Depth Gauge)	4.73		4.37	3.53	6.29
Visual Holiday Detection – System	4.68		3.64	3.48	6.93
Visual Holiday Detection – Primer	4.62		3.60	3.52	6.74
Dry Film Thickness (SSPC PA-2) – Intermediate Coats	4.52		4.32	3.86	5.36
Visual Surface Cleanliness	4.48		2.74	4.52	6.18
Dry Film Thickness (SSPC PA-2) – System	4.42		4.24	3.94	5.09
Dry Film Thickness (SSPC PA-2) – Primer	4.40		4.05	3.86	5.27
Environmental Conditions during cure	4.36		4.52	3.26	5.32
Dust (Tape Test)	4.32		4.25	3.77	4.95
Environmental Conditions Monitoring	4.17		4.37	3.30	4.84
Environmental Conditions during coating application	4.16		4.04	3.26	5.18
Anchor Profile (Testex Tape)	4.13		4.63	3.22	4.55
Dust (Visual)	4.05		2.35	3.76	6.05
Wet Film Thickness	3.89		2.77	2.80	6.09
Substrate Surface Temperature	3.67		3.14	2.95	4.91

Increasing Concern >>>>

Key Take-aways

- For the most part, there is agreement that inspection processes are effective, appropriately priced, and not ambiguous
  - Visual criteria will lead to more disputes and may be less effective at detecting non-conformities
  - Inspections for small areas drive cost
  - Bressle, Testex, and Electrical Holiday inspection are most expensive
  - UV inspection for missed areas is deemed a potential benefit
- Automatic data collection and storage has the potential to significantly impact inspection processes
  - Requires electronic means of measurement

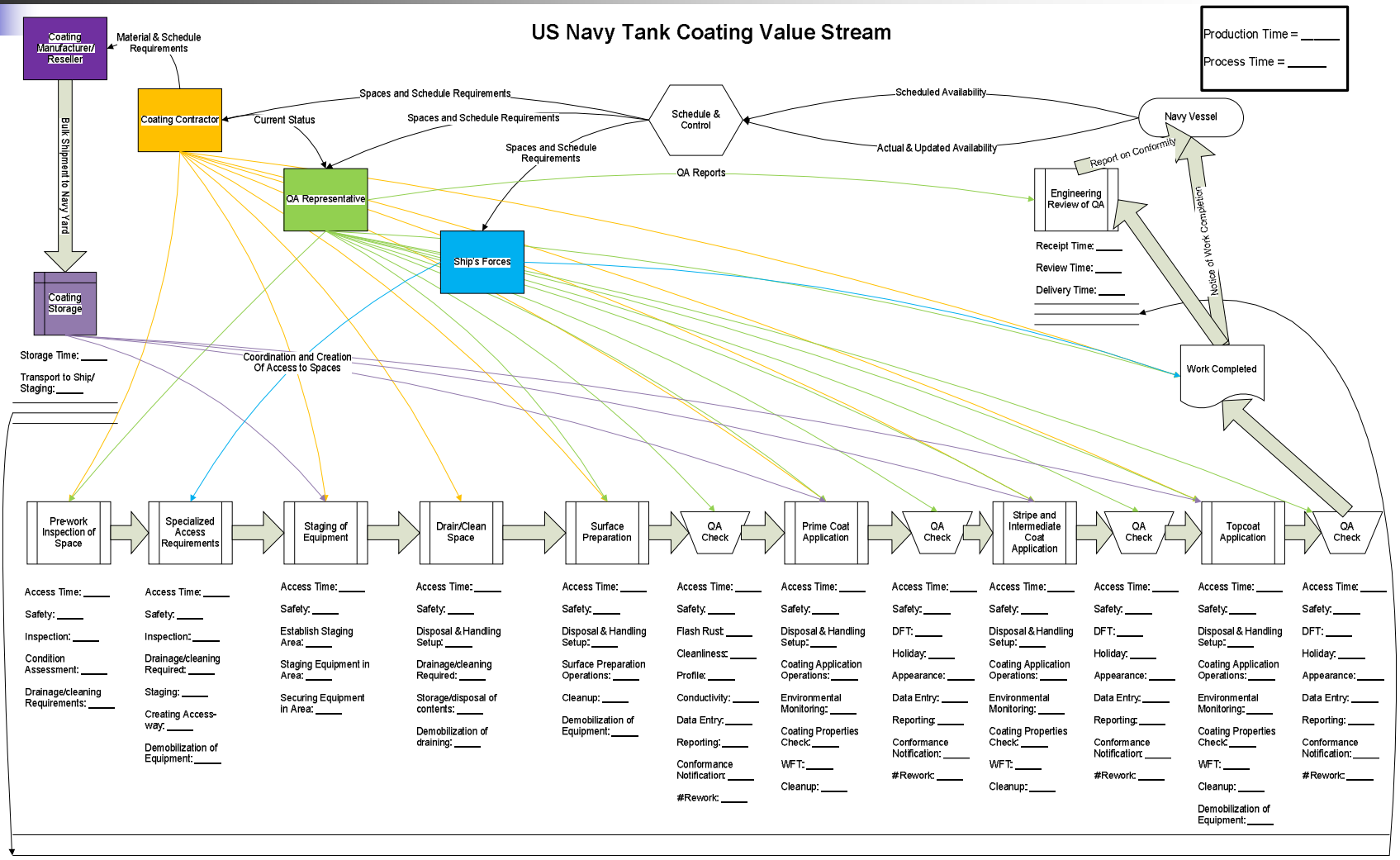
General Take-aways

- Likelihood of failure depends on more than quality.
  - Service conditions, type of material, and other variables impact failure likelihood
- There are several arguments for process control rather than QA/QC.
  - A good, experienced coating inspector will understand how to influence the process within the bounds of an inspector's responsibility – this is really process control
  - Time of detection is a big driver of repair cost. Most things are fairly easy to fix if noticed early enough
- Reporting is a big issue – consistency would help
  - Well defined list of attributes, areas to be inspected, and standardized forms
- There is no such thing as a perfect job
  - Need proper risk assessment when things go wrong (e.g., "acceptable faults")

Process Analysis

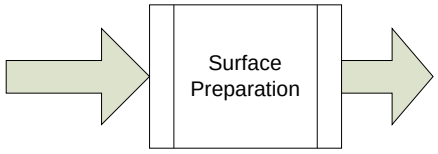
- Evaluate each inspection process
  - Purpose
  - Alternative methods
    - Advantages/disadvantages
  - Detailed process evaluation
  - Data/Results analysis
- Put into context of project
  - Value Stream Map
- Provide rubrics for a facility to perform their own analysis
  - Detail is shipyard specific

Value Stream Mapping



Value Stream Mapping

- Focus on QA Steps
- Delineate Process time form Production Time
- May result in a guideline for Shipyards to use for their own process
- May need to reach out to members for process data



Access Time: 45 min

Safety: 30 min

Disposal & Handling
Setup: 75 min

Surface Preparation
Operations: 240 min

Cleanup: 60 min

Demobilization of
Equipment: 45 min

495 min

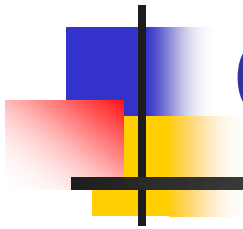
240 min

Demonstration Project

- Targeting July/August at Todd
  - Detailed process evaluation of 009-32 practices versus more automated processes
- Data-logging inspection tools
  - Automated environmental condition monitoring
  - Data-logging DFT gages
  - Data-logging Surface Profile

Summary

- Completed Survey
- Working through process analysis
- Demonstrate process improvement at Todd in July/August, 2007
- Complete project by December 31, 2007



Questions or Comments?

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