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### QUESTIONS AND ANSWERS

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Product Contamination Case Study: Sugar Vessel

**Incident Report**

- The boiling vessel was contaminated with contaminated liquid sugar from the bulk holding sugar vessel.
- The boiling vessel was transferred to the next stage of the process before the contamination was detected.
- No QC was carried out on the bulk tanker delivery before being unloaded.

**Group Work**

- Investigate the root cause of the incident and corrective action to be taken to prevent this occurring in the future.
- Use the HACCP process in this investigation.

*Ref Module 1.1*
Product Contamination Case Study: Vessel Contaminated with Cleaning Detergent

**Incident Report**

- The vessel was cleaned (CIP) and the product then contaminated with cleaning detergent.
- The entire production batch was discarded due to the contamination.
- No inspection was carried out on the vessel prior to filling with product.

**Group Work**

- Investigate the root cause of the incident and corrective action to be taken to prevent this occurring in the future.
- Use the HACCP process in this investigation.

*Ref Module 1.2*
Customer Complaint Case Study: Mouse in Can

Incident Report

- A customer complained that a mouse was found in a 3 months old can of beer.
- Health Inspector logged a formal complaint with the manufacturer and a full explanation was requested to assess if the mouse had been in the can when it left the packaging plant.
- The can was examined in the presence of a team that included a forensic specialist and a mouse was found inside the can.
- A thorough investigation followed to assess the cause of the incident.

Group Work

- Investigate the root cause of the incident and corrective action to be taken to prevent this occurring in the future.
- Use the HACCP process in this investigation.
- What is the implication of Due Diligence in this incident?

Ref Module 1.3
The Passive Film on the Surface of Stainless Steel Case Study: The Passive Film on the Surface of Stainless Steel and the Resultant Corrosion Resistance

Incident Report

- A passive film will form on the surface of stainless steel to result in the primary property of stainless steel namely, its corrosion resistance (passivity).

Group Work

- Explain the passive film on the surface of stainless steel with respect to all factors pertinent and relevant to
  - its formation;
  - all its properties;
  - the resultant corrosion resistance (passivity);
  - why it is so important to be maintained/preserved at all times in the end use application.
- Identify and explain at least three events or actions (other than corrosion) that will impair, damage or destroy the passive film.
- Identify and briefly describe the chemical procedure used to restore the passive film and associated corrosion resistance.

Ref Module 2.1
Corrosion of Stainless Steel Case Study: Leaking of Insulated Pipe Conveying Hot Process Solution

Incident Report

- Plant extensions were carried out to increase the capacity. This involved a significant amount of insulated pipework to convey hot process solution (≈80°C). The pipe was Grade 316, as had been used without any failure in the existing plant for over 5 years.
- Six months after installation, a slight amount of leakage was noticed weeping through the cladding of the insulation. The cladding was opened and the short length of pipe was cut out for examination. The reason for this failure was required quickly in order that repairs could be affected to get the plant back in operation in as short a time as possible.

Group Work

- Examine the above photograph and identify all significant visual features.
- Make a preliminary identification of the corrosion mechanism that has caused the failure.
- Propose any further aspects related or pertinent to the failure, that should be investigated in order to support and confirm the preliminary identification. (Answers will be given to such aspects if they are, in fact, pertinent and relevant.)
- Positively identify the corrosion mechanism that has caused the failure.
- Describe the reason for its occurrence with particular reference to the nature and location of the failure.
- Propose any further investigation that should be carried out before repair work is initiated.
- What must be done to prevent such failure in the future?

Ref Module 2.2
Corrosion of Stainless Steel Case Study: Failed Panel of Plate Type Heat Exchanger

Failed Panel (HE)

Incident report

- Individual panels of plate type heat exchangers were failing after different, but relatively short, time intervals. The failure was more prevalent around the top of the panel, *i.e.* in the installed position.
- The panels were of Grade 304 stainless steel.

Group Work

- Examine the above photographs and identify all significant visual features.
- Make a preliminary identification of the corrosion mechanism that has caused the failure.
- Propose any further aspects related or pertinent to the failure, that should be investigated in order to support and confirm the preliminary identification. (Answers will be given to such aspects if they are in fact pertinent and relevant.)
- Positively identify the corrosion mechanism that has caused the failure.
- Describe the reason for its occurrence, with particular reference to the nature and location of the failure.
- What must be done to prevent such failure in the future?

*Ref Module 2.3*
Corrosion of Stainless Steel Case Study: Corrosion Mechanism

**Incident Report**

- A small ancillary Grade 304 stainless steel vessel is corroding. The corrosion is occurring as small diameter pinholes that perforate the wall of the vessel with an associated negligible general loss of wall thickness.

**Group Work**

- Identify the mechanism of corrosion.
- Explain how this mechanism of corrosion takes place.
- List the process conditions that would expectedly prevail and that should be checked to ascertain if any modification thereto is possible to prevent the corrosion. What are such modifications?
- If such modifications cannot be made, what grades of stainless steel having a progressively higher resistance to this mechanism of corrosion could be considered. How is the higher resistance of such stainless steel assessed/reported.

**Ref Module 2.4**
Fabrication of Stainless Steel Case Study: Audit of Maintenance Workshop I

**Incident Report**
- The maintenance workshop by its very nature has to process and fabricate plain carbon (mild) steel and stainless steel. With the elapse of time a slight degree of ‘familiarity breeds contempt’ is perceived to have occurred.

**Group Work**
- You are the audit team tasked with auditing the disciplined and correct manner in which the stainless steel is being stored, handled, cut and formed.
- Detail the actions and events that you would wish to observe and/or investigate.
- Motivate the workshop management and supervisors to adopt a disciplined approach by explaining the cause and effect related to the actions and events if these are not performed in a correct manner.

*Ref Module 2.5*
Scale Build-up on Surface of Heat Exchanger Case Study: To Assess the Causes of Scale Build-up

Incident Report

- Scale builds up on the inner surface of the tubes of the heat exchanger in a boiling vessel. This can cause a decrease in the heat transfer efficiency, corrosion of the surface and off flavours in the product.
- In the attached photo the surface is clean.

Group Work

- Investigate the cause of build-up on the surfaces.

Ref Module 3.1
Module 3 cont’d…

Cleaning of Vessels using a Manual CIP Cleaning System Case Study: Explain the Principles used in this System and the Main Inspection and Tests to be done to Demonstrate an Acceptable Hygiene Standard and Safety System

Incident Report

- Vessels (photo 1) were cleaned manually: access to surface by ladder. A mobile CIP system (photos 2, 3, 4) is now in use. The above photos show different phases in the conversion from manual to the mobile CIP system.

Group Work

- Describe the steps in the mobile CIP system and recommend an analytical procedure to check for level of hygiene in the vessel after cleaning.

Ref Module 3.2
Biofilm on Vessels are Detrimental to Hygiene Standards Case Study: Explain the Causes of Biofilm Build-up and the Potential Problems Associated with Hygiene and Corrosion

Incident Report

- Biofilm formation at the bottom of the vessel (a) and at the outlet pipe (b) are giving rise to microbiological infection in the vessel and in the pipe.

Group Work

- Define the key factors that contribute to biofilm build-up.
- Define the four factors that contribute to an appropriate level of hygiene in the vessel and pipes.
- Recommend the steps to be taken to eliminate the biofilm from both locations and define how these incidents can be prevented in the future.

Ref Module 3.3
Customer Soil in CIP Vessels is Impacting on Efficiency of CIP Systems Case Study: Assess the Cause of Soil in CIP Vessels

Incident Report

- The CIP system is losing its effectiveness.
- Soil is finding its way into both the caustic and acid detergent vessels and into the recovered water vessel.
- Levels of infection are increasing in the samples taken from the process vessels that have been cleaned.

Group Work

- Investigate the root cause of the incident and corrective action to be taken to ensure the CIP system is effective.
- What is the implication of changing from a multi-use CIP system to a single use system?

Ref Module 3.4
Plant Environmental Survey Case Study: Explain the Reason for Low Microbiological Environmental Results

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<td>Process Area 2: 80% in spec.</td>
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<td>Packaging Area: 75% in spec.</td>
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Incident Report

- Results of the microbiological environmental survey have shown poor results for the third month in a row.

Group Work

- Define the analytical procedures used to determine the microbiological condition of the plant.
- Investigate the root cause of the poor results and recommend an action plan to improve the results.

Ref Module 4.1
Case Studies: Questions and Answers

MODULE 5

Physical Presence of Soil at the Top of Vessel Case Study: Explain Reasons for Soil

Incident Report

- Microbiological results of vessel hygiene have deteriorated.
- Soil was found at the top dome of vessels (see photo) that are equipped with the two types of cleaning devices: spray balls and rotating jet cleaners.

Group Work

- Define the analytical methods used to assess microbiological and organic contamination.
- Investigate the causes of the incident and corrective action to be taken to prevent this occurring in the future.

Ref Module 5.1
Incident Report

- Vessel coating delaminated, causing severe hygiene problems resulting in contamination of the product.
- Investigation into the cause of the incident showed that the coating delaminated in various areas of the vessel and pin holes in the coating material appeared over large surface areas.
- A thorough investigation followed to assess the cause of the incident.

Group Work

- Investigate the root cause of the incident and corrective action to be taken to prevent this occurring in the future.

Ref Module 5.2
Crack on Surface of Process Vessel Case Study: Cause and Implication of the Crack on Surface

**Incident Report**

- A crack was found on the outlet of the vessel. This resulted in product loss and potential failure of the vessel structure.
- Investigation into the cause of the incident showed that the crack had been reoccurring over the last 15 years.

**Group Work**

- Investigate the root cause of the incident and corrective action to be taken to sustain the vessel in operating condition for another 3 years.
- What is the implication of maintaining the vessel in the current condition from a product and operator safety point of view?

*Ref Module 5.3*
Case Studies: Questions and Answers

MODULE 1

Question

1. Which one of the following statements is incorrect?
   a. HACCP is part of risk management.
   b. HACCP is for improving product quality.
   c. HACCP can be used to demonstrate due diligence.
   d. HACCP is aimed at protecting the consumer from harm or illness.

Answer

   b. HACCP is for improving product quality.

Question

2. List three main features of pest control systems for the food and beverage industry.

Answer

   a. Pest control company to be registered with relevant authority.
   b. Site map for the baits.
   c. Baits to be tamper proof.

Question

3. HACCP principles cannot be applied in supermarket chains because people move in and out of the establishment (TRUE/ FALSE).

Answer

   FALSE

Question

4. In HACCP studies, the following steps form part of the preparation for the application of HACCP principles. Rank them by sequence of events.
   a. Scope of the HACCP study.
   b. Product description.
   c. Assemble HACCP team.
   d. Identify target market.

Answer

   d. a. b. c.

Question

5. The formation of ATNC (Apparent Total N-Nitroso Compounds) in beer is due to the presence of nitrate reducing bacteria. Therefore ATNC is a biological hazard (TRUE/FALSE).

Answer

   FALSE
Question

6. The typical standards used to establish whether materials used in food or beverage products are
   a. Food Chemical Codex 4th Edition (FCCIV);
   b. European Scientific Committee for Food (ESCF);
   c. Joint Expert Committee for Food Additives (JECFA);
   d. US Federal Drug Administration (FDA) regulations.

   What is the correct answer?
   A. a., b. and d.
   B. a., b., c. and d.
   C. a. and c.

Answer

B.

Question

7. The steam used in direct heating is generated from potable water. Chemicals are used in treating boiler water. How do you ensure that the generated steam does not compromise consumer safety?

Answer

Chemicals used in boiler water treatment should be quality assured so that they comply with food grade requirements as stipulated in the relevant regulation or international standard.

Question

8. A dairy product has a label with the instruction to keep it refrigerated below 10°C. In HACCP terms
   a. What is the control measure?
   b. What parameter is used in the CCP?
   c. What is the critical limit?

Answer

a. Refrigeration.
   b. Temperature.
   c. <10°C.

Question

9. List four HACCP review triggers.

Answer

a. Increase in specific consumer complaints
b. Change in food legislation.
c. Plant or process modification.
d. Change in raw materials.
Case Studies: Questions and Answers

Question

10. When a hazard has no control measure in place, the process or product should be modified to either
   a. ______________ or b. ______________ the hazard?

Answer

a. Control.

b. Design out.

Question

11. Which HACCP principles are also main elements of the Quality Assurance system?

Answer

a. Document control and record keeping.

b. Deviation and corrective action.

c. System verification through reviews and internal audits

Question

12. For consumer information and awareness, what are the three elements of information that will be
    crucial for consumer safety?

Answer

a. Product handling.

b. Product storage.

c. Product preparation.

Question

13. Identify the regulations that determine Food Safety in your country.
    State the regulations below.

Answer

------------------------------------------------------------------------------------------

(Note: there is no correct answer, the learner needs to identify the regulations.)
Case Studies: Questions and Answers

Question

1. Give the name, the chemical symbol and the approximate minimum amount of the alloying element which, when added to steel, renders it stainless?

Answer

Chromium Cr approximately 11-12%.

Question

2. The corrosion resistance of stainless steel is due to a phenomenon (property) termed passivity. What is meant by passivity? Why does stainless steel exhibit this property of passivity (i.e. what feature)?

Answer

A metal (or alloy) loses its chemical reactivity and becomes inert to many corrosive solutions.
A passive chromium rich oxide film forms on the surface.

Question

3. What is the most common grade of stainless steel used for the manufacture of process vessels, tanks, pipe-work and other components for application in the brewing (and food and beverage) industry?
What is the nominal composition of this grade of stainless steel?
To which classification of stainless steel does it belong?

Answer

- Grade 304 / 304L [1.4301 / 1.4306];
- 18%Cr 8-10%Ni;
- austenitic stainless steel (or Conventional CrNi austenitic stainless steel).

Question

4. Stainless steel flat product (viz. plate, sheet and coil) is used for the manufacture of such equipment as vessels and tanks. The availability of other product forms of stainless steel is of definite advantage for the manufacture of other necessary components and equipment. Give two such product forms and the related components and equipment manufactured therefrom.

Answer

Two of the following:
- castings pumps, valves, pipe fittings;
- pipe and tube tube and piping systems for conveyance of liquids and gasses, heat exchanger bundles, hand railing and stanchions;
- forgings flanges, rings, tube plates, larger shafts and spindles;
- long products as bar for shafts, spindles, fasteners and as sections for pipe racks, cable trays, stairways and walkways.
Question

5. Give three properties that result in a surface being hygienic. Give one associated factor related to the surface of stainless steel which gives it such a hygienic surface property.

Answer

Three of
- clean, sanitary, aseptic, free of germs/bacteria, sterile, healthy.

One of
- surface that is non-porous and non-absorbent, thus preventing growth of germs and bacteria and their carry over from batch to batch;
- surface that is unaffected (i.e. not roughened, pitted) by the wide variety of liquids encountered both in production (e.g. acids, juices, spices, salts) and also by the cleaning and sterilising solutions employed;
- surface that is tolerant of both high and low temperatures and resistant to thermal shock.

Question

6. On what three factors does the severity and extent of aqueous corrosion depend?

Answer

- The concentration of the aggressive substance/s in the corrosive solution.
- The temperature of the corrosive solution.
- The presence and nature of contaminants and trace elements contained in the corrosive solution.

Question

7. Which is considered the least dangerous mechanism of corrosion and why?
   - A reported corrosion rate for grade stainless steel in a specific corrosive solution is 0.06mpy. What does this mean? Does this indicate that this grade of stainless steel is suitable (resistant) in this corrosive solution?
   - Why should reported corrosion rates be used with caution and as guidelines only?

Answer

- General Corrosion, because the rate of corrosion is measurable and predictable.
- The loss of thickness due to corrosion occurs at a rate of 0.06mm per year.
- The grade of stainless steel may be considered as highly suitable (resistant).
- General Corrosion rates are often determined under laboratory conditions using chemically pure solutions. Therefore, the effect of contaminants and trace elements that are usually present in actual applications, are not taken into account

Question

8. What are the general features associated with Pitting Corrosion?
   - Which aggressive substance is contained in the corrosive solutions that most commonly causes Pitting Corrosion?
   - Is Pitting Corrosion more likely to occur in acidic or basic corrosive solutions?
   - Is Pitting Corrosion more likely to occur in corrosive solutions at ambient or elevated temperatures?
Case Studies: Questions and Answers

Answer

- Pitting Corrosion is a very localised and dangerous form of corrosion that results in small holes or perforations with little to negligible measurable general metal loss.
- The chloride (Cl) ion.
- More likely in acidic corrosive solutions.
- More likely in corrosive solutions at elevated temperature.

Question

9. Which classification (or examples of grades) of stainless steel are considered to be the most susceptible to the mechanism of Stress Corrosion Cracking (SCC)?
   - What is the aggressive (insidious) ion contained in the corrosive solution that is the primary cause of SCC in these stainless steels?
   - Why is the word 'stress' included in the term Stress Corrosion Cracking?
   - It is often said that a temperature of 50°-60°C is required for SCC to occur. Is this in fact a minimum threshold temperature below which SCC will not occur?

Answer

- Conventional austenitic stainless steel (e.g. Grades 304/L, 316/L).
- The chloride ion (Cl).
- Because SCC will only occur if a tensile stress exists in the stainless steel.
- No - SCC can occur at lower temperatures.

Question

10. Failure of insulated stainless steel vessels (or pipes) containing (or conveying) process solutions at approximately 80°C has occurred. On removal of the insulation, very fine, highly divergent cracks are observed in the stainless steel surface that was in contact with the insulation. Some of these cracks have propagated through the wall of the vessel (pipe).
   - From the appearance (nature) of the failure, what mechanism of corrosion would you suspect to have taken place?
   - What would you expect to find present in the insulation?
   - How would this aggressive substance have got into the insulation?
   - Give at least three preventative measures to avoid failure of this nature.

Answer

- Chloride Induced Stress Corrosion Cracking (Cl.SCC).
- The chloride ion (and damp insulation that has not become damp because of the leaking from the process side).
- Present (contained in) the original insulation
  - introduced into the insulation by leakage of wash water through the ineffectual cladding of the insulation (each such cyclic of leakage into the insulation brings with it some chloride that is concentrated by evaporation to high levels, i.e. the evaporative effect).
- Three of the following:
  - the insulation used must be 'chloride free';
  - the insulation must be kept dry;
  - the cladding of the insulation must be fully sealed to prevent ingress of wash water (especially properly repaired if removed during maintenance or damaged);
  - the surface of the stainless steel in contact with the insulation coated with anti-stress corrosion lacer;
  - a barrier (water impervious) film wrap between the surface of the stainless steel and the insulation;
  - aluminium foil between the surface of the stainless steel and the insulation (also acts as sacrificial anode).
Case Studies: Questions and Answers

Question

11. What do you understand by the term ‘mechanical damage’ as that which occurs during the fabrication of stainless steel?
   • Give examples of ‘avoidable’ and ‘unavoidable’ mechanical damage.

Answer

➢ The passive film on the surface of the stainless steel is impaired or removed by mechanical means.
➢ Avoidable = scratches, gouges, weld spatter, arc strikes, unnecessary grinding.
   Unavoidable = creation of a new surface by cutting or necessary grinding.

Question

12. What do you understand by the term ‘ferrous contamination’?
   • Give four causes of ferrous contamination.
   • What is the result of ferrous contamination.

Answer

➢ Ferrous contamination is contamination ‘on’ or ‘in’ the surface of the stainless steel by particles or substances which contain iron.
➢ Four of the following:
   – contact of the stainless steel with mild steel racks;
   – debris from mild steel stored in the rack above the stainless steel;
   – from handling/forming/cutting equipment surfaces contaminated by having been previously used for mild steel;
   – abrasives that contain iron;
   – abrasives having previously been used to grind mild steel;
   – mild steel flyover or in particles in grinding stream;
   – temporary attachments of mild steel.
➢ On exposure to the environment the ferrous contamination ‘rusts’ as would ordinary plain carbon (mild) steel, resulting in staining of the surface. Passivity is also impaired and it is more likely for corrosion to initiate.

Question

13. During welding the metal adjacent to the weld (i.e. within the weld zone) will be heated to within a range of high temperatures.
   • What effect can this have on the surface of the stainless steel?
   • What is the result of this effect with respect to the passive film and why?
   • How can this effect be prevented (i.e. techniques, welding processes and precautions related thereto)?

Answer

➢ The surface of the stainless steel will be oxidised (scaled).
➢ High temperature oxidation destroys the passive film. Oxidised (scaled) surfaces are not passive nor will a passive film form thereon. Corrosion will therefore readily initiate because the high temperature oxide formed as compared to the passive film, has a different chemical composition, is much thicker than the passive film and is cracked and porous.
➢ Oxygen must be excluded from the surface by perfect shielding with an inert gas during the exposure to the high temperatures, by using inert gas shielded welding processes and/or shielding the surface with supplementary inert gas shrouds (e.g. purge dams).
   – The shielding gas must be of high quality (e.g. very low oxygen content).
   – The shielding gas must not be disturbed by draughts.
   – The stainless steel surface should be shielded until the temperature thereof drops below ≈500 °C.
Question 14. What is meant by the term ‘pickling’?

- Why is it done?
- What surfaces should be treated by pickling?

Answer

- It is a chemical treatment of the surface using an aggressive acid mixture.
- It is used to dissolve the impaired (destroyed) passive film on the surface of stainless steel in order to produce a new unaffected surface on which the passive film can develop (or can be developed).
- Surfaces which have been oxidised (scaled) due to the exposure to oxygen (as in the air) whilst heated to high temperatures during the welding process or thermal cutting.
  - Surfaces which exhibit heat tints, as in grind marks and polishing lines or are at a greater distance from the weld and/or on the back surfaces opposite to where welding has been done on the front surface.
  - Also surfaces that have been contaminated (more especially those where the contamination has been forced into the surface) and surfaces that have developed heavy staining due to contamination.

Question 15. Why should the surface of the stainless steel be cleaned before pickling (and/or passivating)?

- Passivating is also an acid treatment of the surface of stainless steel. How is it done and what is its purpose?

Answer

- Cleaning should be done to remove general contaminant from the surface. If these are not removed they could
  - impede the pickling process by acting as a surface barrier;
  - react with the acid pickling solution to cause very corrosive conditions;
  - cause staining of the surface;
- Passivating is an acid treatment using an oxidising acid, namely nitric acid (HNO₃).
  - It is done to enhance the development and integrity of the passive film in as short a time as possible.
  - Also, it is recommended that surfaces created by mechanical means should be passivated.
  - A passivating treatment will dissolve any free/loose, light ferrous contamination which is ‘on’ the surface.

Question 16. Give the sequence of operations that result in a No.2B surface finish on stainless steel coil or sheet.

- What is the main difference in this sequence of operations in order to give a No. 2BA finish?

Answer

- Material is first hot rolled, annealed (heat treated), pickled and passivated to remove the high temperature oxide (scale) from the surface. Then the material is cold rolled to the required thickness. The resultant work hardening is removed by annealing, followed by pickling and passivating to remove the high temperature oxide (scale) from the surface. The surface has a dull matt finish. A subsequent light skin pass (only slight reduction) will smooth and brighten the surface to a semi-reflective finish.
- The annealing after cold rolling is effected in a closely controlled inert atmosphere. Therefore, no high temperature oxidation (scaling) occurs and no subsequent pickling, passivation and skin pass is necessary and the bright smooth surface as produced by the cold rolling is preserved.
Question

17. What is a notable feature regarding the surface roughness ($R_a$) values reported for the abrasive mechanically produced polished finishes?
   - What are the factors that affect the surface roughness ($R_a$) values, what are the possible reasons for this?
   - What is therefore important with regard to the specification of the required surface roughness?

Answer

- The reported surface roughness ($R_a$) values given for the different (but same) abrasive grit size vary to a significant degree.
- The actual surface roughness attained in abrasive mechanical polishing is dependent on
  - the type, shape of the abrasive grit and how quickly it wears/blunts;
  - wheel vs. belt polishing;
  - hand vs. machine polishing (contact pressure and consistency thereof);
  - the grade of stainless steel being polished;
  - the polishing lubricants used;
  - the increments in the sizes of the abrasives used in the successive stages of polishing.
- Neither a designated surface finish nor grit size can be used as the basis of specification for a desired (required) surface roughness.

Question

18. What is the primary effect of abrasive mechanically polishing stainless steel?
   - One of the secondary effects of abrasive mechanically polishing stainless steel is that high temperatures are generated within the surface layers of the polished surface. Why does this occur? What is the result? What should be done?

Answer

- Mechanical abrasive polishing will completely remove the extremely thin passive film from the surface of the stainless steel.
- Because stainless steels are poor conductors of heat
  - high temperature oxidation of the surface can occur (often visible as only the palest straw coloured heat tint);
  - such oxidised (heat tinted) surfaces are not corrosion resistant and cannot self-passivate.
- The surface needs to be pickled and passivated to fully restore the passivity (corrosion resistance) of the surface.

Question

19. In the electro-polishing process, the surface of the stainless steel is actually being dissolved due to it being the anode of an electrolytic cell. How does the surface develop its passivity?
   - Give the major benefit and two further benefits of electro-polishing stainless steel.

Answer

- In the process, a blanket (cloud) of oxygen is formed at (around) the anode surface (i.e. the surface being polished). When the current is switched off the now active surface of the stainless steel (i.e. devoid of a passive film) absorbs oxygen from this accumulated surrounding blanket to develop a highly superior passive film.
Case Studies: Questions and Answers

Electro-polishing passivates the surface of stainless steel to a greater extent than any other passivating treatment (i.e. the best possible passivity [corrosion resistance] results from electro-polishing):

- excellent hygiene and cleanability of the surface, particularly with respect to the ability of the surface to be sterilised;
- the surface is smoothed (scratches and gouges are not removed - burrs are removed);
- a surface of lower friction with lesser tendency to gall or seize;
- a surface with good light and heat reflectivity with fair specular reflectance;
- a surface less likely to pick-up or snag fine solids, particles or fibres;
- the ability to polish small and complex shapes and the inside surfaces of small ID hollow components.

Question

20. Comment, with respect to the surface finish of welded pipe/tube and cast components.

Answer

The surface finish of pipe and/or tube is dependent on

- the surface finish of the original coil (either hot or cold rolled depending on thickness);
- whether or not annealing after welding was performed;
- the atmosphere employed (if air pickling and passivating required, if inert pickling and passivating not required);
- the 'as produced' surface finish can vary from being similar to a No.1 – No.2D – No.2B;
- mechanical polishing can be applied to the outside surface.

The surface finish of castings is dependent on the surface texture and finish of the mould cavity. The surface finish improves sand moulds -> shell moulds -> investment (lost wax) moulds.
- The surface finish of castings is, in general terms, difficult to modify by mechanical means due to the (normal) complex shape of the castings. Electro-polishing will improve the surface finish.
Case Studies: Questions and Answers

MODULE 3

Design of Process Plant

Question

1. What are the key factors that determine an acceptable design of a process vessel?

Answer

• Design and fabrication must conform to appropriate hygiene standards defined by, for example, EHEDG (European Hygienic Engineering & Design Group).
• Dimensions of the vessel must allow for effective cleaning by manual or CIP process.
• Access to the vessel must allow for safe inspection of the vessel’s interior and exterior surface and fittings.
• Selection and positioning of the spray device must allow for the cleaning liquids to make contact with all the surfaces to eliminate the soil.
• All internal fittings and agitators must be cleanable.
• Internal surface finishes must allow for appropriate levels of hygiene to be achieved during the cleaning process.
• Fall of the bottom of the vessel must allow for complete draining of the vessel.

Question

2. What are the key factors that determine an acceptable design of a piping system?

Answer

• Type of stainless steel: AISI 304 or 316 depending on required corrosion prevention.
• Selection of pipe finish and its internal surface roughness: roughness with Ra 2.4 requires three times more time to clean than a surface with 0.42 Ra. Biofilm starts to build up after one cycle of use (process and CIP).
• Dimension of piping will influence the flow speed of the product: to ensure a clean surface after CIP, the flow speed in the pipe must be, for example, 2.5 meter/second for 80mm ID pipe.
• Supports and anchors of the piping must allow for gradients that permit total draining of the pipe.
• Expansion and contraction of pipes must be considered to avoid damage to the pipes, supports and anchors.
• Water hammer must be prevented to ensure valve seats do not lift that can cause contamination of the product.
• Welding quality must be ensured: most frequent weld failures are
  – misalignment;
  – cracking;
  – porosity and inclusion;
  – incorrect penetration;
  – lack of side wall fusion;
  – lack of gas shield in orbital welding.
• Flanged joints must be flush with the inner bore of the pipe and the material must be of food grade.
• Joints and seals (elastomers) must be selected and installed to ensure hygienic characteristics are not compromised by avoiding
  – over compression that destroys the material;
  – compression that creates crevices;
  – misalignment that creates pockets of soil and microbes.
• O-rings must be mounted to ensure that the area of steel covered by the rubber at the product side is not influenced by thermal expansion.
• Pipe reducers must allow for drainability.
Hygiene Factors

Question

3. What are the key factors that ensure appropriate hygiene in the plant?

Answer

- Mechanical factor:
  - quantity of the soil to be removed from the surface;
  - flow rates;
  - turbulence;
  - shear stress;
  - pressures and pressure drops;
  - water hammer prevention (lifts seats on valves allowing CIP into product line);
  - efficiency of flow and pressure measuring instruments.

- Chemical factor:
  - quantity and quality of the soil to be removed from the surface;
  - initial concentration as measured and efficiency of conductivity meter;
  - topping up in the circuit;
  - presence of solids in solution;
  - dilution in circuit;
  - neutralisation, e.g. CO\textsubscript{2} by caustic;
  - return to holding vessel or drain in multi-use system.

- Temperature:
  - initial temperature as measured;
  - controlling in the circuit;
  - cooling in the circuit, e.g. pass over cold surface of process vessel;
  - return to holding vessel or drain in multi-use system;
  - efficiency of temperature control.

- Time:
  - for complete process as measured;
  - to wash out or rinse the previous chemical or product;
  - for chemical to react on surface soil;
  - to drain the detergent in the bottom of the vessel;
  - to sequence CIP and CIR pumps;
  - to sequence opening and closing of automated valves;
  - efficiency of time control.

Question

4. What is biofilm and why is it important to eliminate it from the surface to obtain a hygienic plant?

Answer

- Biofilm and where it grows:
  - microbes create niches or micro-environments on the irregularities of the surface by creating biofilm;
  - biofilms are organised microbial systems consisting of layers of microbial cells associated with the rough surfaces on the vessel and pipe walls but they will also build up on smooth surfaces;
  - if pipes flow speeds are low, biofilm will build up on the wall surface.

- The importance of eliminating biofilm:
  - biofilms are detrimental to the cleaning process as they harvest and protect the inner surface of the cells from cleaning and sanitising fluids;
  - biofilms corrode surfaces of stainless steel and leave pockets where microbes will survive.
Question

5. What are the main differences between spray balls and rotating spray cleaning devices?

Answer

- Spray balls rely on the showering with a curtain of cleaning fluid over the entire surface of the vessels to remove the soil. The fluid is pumped continuously over the surface or in short bursts.
- Rotating spray cleaning devices rely on the high pressure jets to impinge the cleaning fluids onto the surface of the vessels to remove the soil. The fluid is pumped continuously at the same time as the rotating device directs the jet at a different point on the surface. At the end of the total cleaning cycle, the entire surface has been in contact with cleaning fluid a number of times.
- The different systems can be compared with the following data from the corresponding devices used on a vessel with the same dimensions:
  - spray ball for 5,2 meter diameter vessel: flow rate of cleaning fluid 350Hl/hour at 1,5kg/cm²;
  - rotating jet cleaning device for 5,2 meter diameter vessel: flow rate of cleaning fluid 240Hl/hour at 6kg/cm².
Plant Environment

Question

1. What features of the buildings impact on the overall hygiene environment of the plant?

Answer

- Floors must be durable and acid and caustic resistant with a fall of 1-1.5% to the drains.
- Walls and ceilings must be coated with a surface that will allow for regular washing down and sanitation.
- Drainage systems must be easy to clean and installed with air traps and with sieves to retain glass and other solids where applicable.
- Plant supports, access walkways and ladders/stairs must be made from corrosion resistant material or coated with a corrosion resistant paint.
- Ventilation of all process areas must allow for the required air movements to prevent mould growth and eliminate odours.
- Walls and structures must be designed to avoid protrusions to prevent dust or soil build-up that cannot be cleaned.
- Insects and vermin must be prevented from entering the plant by installing suitable covers to all access points in the building.
- Hot and cold water points must be located at strategic points in the plant to allow for cleaning of all surfaces.
- Ablutions must be positioned away from the process areas. They must be furnished with facilities that allow for effective personal hygiene of all personnel.
Measurement and Inspection

Question

1. What are the key inspection techniques used to assess if cleaning systems are working correctly?

Answer

› Physical inspection of the plant must be carried out to ensure the following:
  - materials storage areas are clean and data of all batches of the materials are recorded and made visible;
  - process conditions (e.g. time and temperature) for the cleaning systems are defined and operating correctly;
  - plant and measuring devices are operating correctly;
  - the four hygiene factors are functioning correctly.
› Chemical inspection:
  - raw materials are analysed for infestation and contamination;
  - cleaning materials and additives used in the heating and cooling media all have the MSDS documentation on site;
  - concentration of cleaning materials (detergents and sanitisers) are monitored and recorded: suppliers’ quality certifications of materials are checked against specification and recorded;
  - analytical data of Customer Complaints recorded along with the corrective action and feedback report to the client.
› Surface measurements:
  - that microbiological control of all surfaces in contact with the product is carried out to the specifications defined in the manufacturers’ methods (e.g. vessels, pipes, heat exchangers);
  - that microbiological control of all surfaces not in direct contact with the product is carried out to the specifications defined in the manufacturers’ methods (e.g. walls, floors and drains);
  - that microscopic examination of soil is done;
  - that roughness of the surface and the surface integrity of the coated surfaces in the process equipment are checked.

Question

2. What tests are carried out on the surface of a process plant to assess if it is clean?

Answer

› Samples for presence of microbes or organic matter:
  - Microbiological samples:
    • presence of bacteria;
    • presence of culture yeast;
    • presence of wild yeast;
    • presence of B. Coli;
  - Organic matter:
    • ATP swab test;
  - Microscopic examination:
    • sample of soil viewed under the microscope to determine its composition: organic, inorganic or micro-organic.
Question

3. What three non-destructive tests (NDT) would you use to assess the roughness and integrity of process plant surfaces for use in a hygienic plant environment?

Answer

- **Surface finish:**
  - two dimensional surface measurement using a Surtronic Display transverse system that measures the surface roughness: roughness of surface finishes impact on the formation of biofilm;
- **Inspection of coated vessel surface:**
  - Holiday detector checks for pinholes in the coated surface, which lead to delamination of the coating with serious impact on hygiene and product contamination;
- **Dye penetrant testing:**
  - dye penetrant testing of metal surfaces highlight cracks or pinholes in the metal structure and weld defects; these in turn, harbour microbes and eventually can also lead to failure in the vessel or pipe.

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