



**SOCIETY OF MAINTENANCE AND RELIABILITY PROFESSIONALS  
CERTIFYING ORGANIZATION**

## **Candidate Guide for Certification and Re-certification**

Second Edition  
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**ANSI Accredited Program  
PERSONNEL CERTIFICATION  
#0739  
Certified Maintenance & Reliability Professional**

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This **Candidate Guide for Certification and Recertification** supersedes the Third Edition of the **SMRPCO Reference Guide** (Copyright 2006) by the SMRP Certifying Organization (SMRPCO) and the First Edition of the **Candidate Guide for Certification and Re-certification** dated 1 May 2007

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For further information about the SMRP Certifying Organization and its programs, please refer to the SMRP web site at [www.smrp.org](http://www.smrp.org).

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**SOCIETY OF MAINTENANCE AND RELIABILITY PROFESSIONALS  
CERTIFYING ORGANIZATION  
Candidate Guide for Certification and Recertification**

**I. Certification**

**A. Statement of Purpose** The Society for Maintenance and Reliability Professionals Certifying Organization (SMRPCO) is organized for the purpose of fostering high standards of ethical and professional practice in the delivery of services through a recognized, credible credentialing program that assures the competency of practitioners of Profession. The underlying ethic upon which the certification process rests is absolute fairness and equity in the administration of examinations and recertification for all applicants without discrimination. (i.e. because of age, color, creed, gender, ethic or religious background, lifestyle, marital status, national origin or political affiliation, race or sexual orientation.)

**B. Rationale for Certification: Achieving the SMRP Mission** The key elements of SMRP's mission are the improvement of the maintenance and reliability profession and supporting the education of maintenance and reliability practitioners.

From the first days of SMRP, it was clear that there were no consistent, well-defined standards for the body of knowledge and capabilities that maintenance and reliability practitioners should have to be effective. Further, there was no way to differentiate those who have mastered the various elements of excellence from those who simply hold the job. SMRP realized that without a well-defined body of capabilities and a method of assessment it could not realistically fulfill all elements of our mission.

Improving the profession requires a standard of excellence and an incentive to attain the standard. Maintenance and reliability managers are often promoted because of technical skills, without regard for their ability to improve work processes, create change, or manage people. SMRP believes that maintenance and reliability practitioners need greater stature and credibility in their organizations and industry to be heard. We believe the message of Maintenance and Reliability adding value is often drowned out by day-to-day production demands.

**C. Benefits of Certification** The benefits of certification are apparent for many fields and very attractive to practitioners in many organizations. The following is a short summary of the benefits that were highlighted by practitioners who responded to the certification survey in 1999 and reinforced by subsequent experience of those who have become certified since 2001:

- Clearer direction for career development and education
- Improved visibility and recognition within your current organization
- Differentiated pay scales
- Portable job skills and knowledge between plants and companies
- Assists in job promotion
- Greater job effectiveness
- Fewer frustrations with gaps in knowledge

- Improved ability to differentiate between candidates in the hiring and promotion process.
- Improved on-the-job training and outside training effectiveness.

In support of increasing the recognition and assurance of the capabilities of maintenance and reliability professionals, SMRPCO has developed and continued to improve a certification process for maintenance and reliability management. The CMRP exam has become the international standard measure of competence in our field.

Many are aware of other organizations that offer similarly titled certifications in this or other related subjects. How does SMRPCO's process differ from these?

- SMRP is an independent, practitioner-based, non-profit organization without ties to any commercial venture.
- The SMRP body of knowledge comprehensively addresses and examines equipment reliability and maintenance (R & M) as well as overall asset management, people and technical skills, as opposed to other programs that deal strictly with the technical aspects of R & M. SMRP sees this as an ongoing effort which requires periodic update (every 5-6 years) using the same process used to develop the original Body of Knowledge. Accordingly the SMRP has established a permanent Maintenance and Reliability Knowledge Committee of volunteer subject matter experts to carry on this work for the CMRP designation as well as others that may be developed. The effort is supported by paid staff. After over a year of preparation, a new Job Task Analysis survey is being conducted as this is written so as to be completed in 2008. Results in the form of an updated Body of Knowledge will be published as soon as possible after the survey results are analyzed and assimilated.
- SMRP uses broad representation in developing its Body of Knowledge and related certification program. Some of the leading organizations in manufacturing and service delivery, utilities, government activities and in the academic world participate on a regular basis to assure thorough validation of the work to develop the certification process.
- In September 2007 SMRPCO was accredited by the American National Standards Institute (ANSI) which uses the International Standards Organization (ISO) guidelines in ISO/IEC Standard 17024) for accreditation of certifying activities as its guide, a distinction not shared by other certification organizations in the field of maintenance and reliability.
- SMRPCO was set up by SMRP and continues to be sponsored by SMRP, the leading organization for maintenance and reliability practitioners. SMRPCO has its own budget, Board of Directors and Staff and operates its program with minimal oversight from its sponsoring organization. No other organization in our field has that distinction.
- SMRPCO plans to enhance the value of certification to certified practitioners through other advanced certifications.

#### **D. Background:**

SMRP decided in the mid-1990's to recognize those individuals who through study, training and work experience have attained a high degree of proficiency in the application of engineering and

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management principles to the maintenance and reliability of commercial, government, industrial and institutional fixed or mobile assets and machinery

Serious efforts towards developing a certification process began after an SMRP Strategic Planning meeting held in August of 1997. In this meeting the organizational structure of SMRP was changed to empower its directors to achieve the mission approved by the SMRP Board of Directors and Officers. The SMRP Board endorsed the certification goal of the Professional Certification Committee (PCC), and appointed Brad Peterson, originator and the main promoter of the idea of a certification scheme, as the Committee Chairman. In 1998 a team of volunteers gathered in Bowling Green, Kentucky to create a charter, objectives, activities and goals of the new PCC.

The next task undertaken by the PCC was to determine what a professional practitioner in the field of maintenance and reliability (M & R) needed to know to be considered a true professional. SMRPCO engaged the services of consultants in the fields of job task analysis and testing for certification to guide their efforts and provide needed expertise which M & R practitioners generally do not possess.

By early 1999, the PCC had identified the capabilities of high performing people leading Maintenance and Reliability initiatives. Approximately 400 maintenance and reliability practitioners who completed a job task analysis survey subsequently validated these capabilities. The majority of survey responses were very supportive of developing a certification process. Respondents overwhelmingly said that these and a few other capabilities are important. The PCC received nearly 20 pages of comments that encouraged the organization to proceed! With the aid of expert consultants this material became the basic Body of Knowledge for the M & R professional, the first ever aggregation of such information in a single document.

The PCC developed a strategic plan for certification by late 1999. It received a green light from the SMRP Board to proceed with creating an evaluation process, an administration process, a testing scheme and a way to market the program to all interested parties.

In the first half of 2000, the development team worked hard to develop definitions, references, certification test questions, methods, and documentation of the testing process.

Volunteer applicants took the first public beta exam during the 2000 SMRP Conference in Cleveland, Ohio. The results from this exam helped validate the exam content and improve it for use in the official certification exam.

The PCC was renamed the SMRP Certifying Organization (SMRPCO) in October 2001, This was to clarify SMRP's role as the sponsoring organization and SMRPCO as the certifying organization that manages the certification program. Independent administration of the certification process is required to ensure impartiality, eliminate the possibility of bias, and for accreditation of the process by third party organizations. SMRPCO has its own Bylaws, Officers, Board of Directors and budget execution authority.

In October 2001, the first official certification exams were conducted.

As mentioned above, SMRPCO was accredited as a Certifying Activity in September 2007 under Standard 17024 established by the International Standards Organization of Geneva, Switzerland. Auditors from the American National Standards Institute of Washington, DC conducted the two-day audit after a thorough study of SMRPCO's application containing nearly 1000 pages of data, procedures, policy documents and related information.

Exams continue to be developed to test candidates' competency in terms of their knowledge, skills and experience in fields common to reliability engineering and maintenance management. The exams are directed toward, but not limited to, individuals who make decisions to improve the reliability and maintenance using generally accepted principles of these fields. The SMRPCO certification exam's focus is on applied knowledge. The study of references alone is highly unlikely to ensure success on the certification examination. Statistics from years of exam administration has shown a high correlation between applied experience and success on the exam.

By the Fall of 2007 over 3000 exams had been administered to professionals from 21 countries and counting. About 2000 professionals have successfully completed the exam. Both the quantitative data and the inputs from the examinees suggest that the exam is fair, challenging and a good measure of the competencies necessary for the professional practitioner.

Successful participants are awarded a certificate of recognition for having achieved a passing grade on the exam and are entitled to apply the designation associated with specific certification to their name and list of accomplishments -- Certified Maintenance and Reliability Professional – CMRP.

#### **E. Exam Venues**

Paper and Pencil Based Tests The examination for certification as a maintenance and reliability professional has been offered at many venues each calendar year, with one of the venues always being the SMRP annual conference, held each Fall. Where possible and practical, examinations will be coordinated with other SMRP activities, such as SMRP Chapter events, Executive Meetings and in conjunction with SMRP sponsored workshops to reduce travel for persons who plan to participate. Third party venues are also scheduled when proper conditions for conducting an exam are assured. All currently scheduled venues are listed on the SMRP website. The examination registration form is available on the SMRP web site by clicking on the "SMRP Certification" tab and following the "Register for the CMRP Exams –More Information prompt to the venue listing. Click on the venue chosen and the registration form will be made available for downloading. At the present time you must access and download the form for mail or Fax submission In 2008 you will be able to complete your registration online.

Computer Based Testing (CBT) The CMRP exam is now available to take at an approved CBT venue. Schroeder Measurement Technologies is SMRPCO's testing partner and manages the CBT testing. To see a listing of CBT venues visit the following website: <http://www.isoqualitytesting.com/locations.aspx>; to register for a CBT venue visit the following: [http://www.smttest.com/smrp\\_registration/](http://www.smttest.com/smrp_registration/). The CBT exams are available during the following months: January, April, July and October. These exams are given at a venue where a proctor is present. A calculator will be provided and results will be sent within four weeks.

**F. Overview of the Certification Examination Process** The Examination for Certification in Maintenance and Reliability Management consists of 110 multiple-choice questions. Examinees are allowed two hours to complete it. The examination is closed book with no reference materials allowed in the examination room (except strict translation dictionaries for candidates whose native language is not English, under conditions specified in Section II of this guide). A hand-held or computer screen based calculator (used during the CBT exams) with arithmetic functions is provided for use by those sitting for the exam. No other personal calculators, computers or electronic devices are permitted.

A set of sample exam questions is provided in Appendix A to this document. These are typical questions that will give the candidate exposure to the format of questions that are included on the exam. These sample questions will not appear on certification exams.

**G. Statement of Policy with Respect to Training Courses. Publications or Other Offerings Related to Certification in the M & R Profession**

SMRPCO will not offer any training to assist persons in preparing for the certification examinations. A foundational belief in developing this examination is that professionals in the maintenance and reliability industry receive their experience and training from a variety of sources, both on the job and from outside training. Therefore, there are no experience or educational requirements set for the exam.

The examinations are designed to test both knowledge and experience. In general, knowledge is not something that was recently learned. It is experience and training that has been applied, tested and analyzed.

Further, the Maintenance and Reliability Body of Knowledge, upon which the exam is based, is very broad. SMRPCO strongly advises that a course of one or two weeks or even months will not adequately prepare candidates to successfully complete a certification examination.

As such, SMRPCO will not develop any training courses to assist persons in successfully completing certification exams. SMRPCO's functions are:

- development and administration of examinations that reflect, to the degree possible, the current Maintenance and Reliability Body of Knowledge, and
- Administration and conveyance of results and credentials associated with certification examinations and subsequent re-certification requirements.

SMRPCO has developed and keeps current a list of publications on maintenance and reliability subjects. The list is available for downloading from the SMRP web site. See the SMRP Certification Page of the web site for information.

The web site also leads users to links which aid those interested in purchasing maintenance and reliability references to vendors that sell them. Inclusion, mention or listing of a reference on the web site does not imply an endorsement of the reference or the vendors in any way.

SMRPCO does not endorse any outside person, preparation course or product (such as a book, compact disc-based offering or other publication including those mentioned above on its web site) in connection with any certification program.

#### **H. Glossary:**

1. **Associate**: Any individual Volunteer (Certificant) or Special Needs Member, Headquarters Staff employee, Consultant or Representative of Sustaining Sponsor Organizations engaged in board, committee, or working group activities of SMRPCO.
2. **Certificant**: Any person holding the designation “CMRP” or other designation established by SMRPCO who is in good standing, defined as a person who has been awarded a certificate good for an initial three (3) year period, and/or a person who has successfully completed necessary re-certification requirements prior to completion of the initial and within each three year period thereafter, shall be designated a Certificant of SMRPCO. Certificants may serve as “Volunteer Members.” Certificants may vote at the annual Meeting of SMRPCO on matters brought before it and separately for one Director of the Board. Rights and responsibilities of Certificants are provided in the SMRPCO Policies and Procedures Document
3. **Certification Cycle**: A three (3) year cycle beginning from the date of the issue of the initial certificate upon achieving a passing score on the specified certification examination and specified on the associated certificate. Subsequent cycles of three (3) years each begin at the end of the period above when re-certification requirements have been met and a new certificate is issued.
4. **Committee**: Has an assigned function for SMRPCO that is on-going.
5. **For Cause**: Failure to comply with SMRPCO’s Code of Ethics, Standards of Conduct, statements of responsibility with respect to anti-trust, confidentiality and non-disclosure and commitments to Board and committees to which assigned and good stewardship, definition of good standing, policies, procedures, bylaws, national, state, provincial and local laws.
6. **Good Standing**: Certification status is current with no disciplinary actions or outstanding financial claims by SMRPCO or SMRP affecting the Certificant’s status.
7. **Guidelines**: Approved, non-binding statements used to direct the procedures and standards.
8. **Policy**: A decision which obligates actions or subsequent decisions on similar matters.
9. **Proctor**: An individual who is approved by the SMRPCO Exam Administration Committee to oversee and/or administer a certification examination.
10. **Signatory**: An individual who commits to an agreement or certifies understanding of contents of a document by affixing his or her actual or electronic signature to it. Such documents include but are not limited to Code of Ethics, Standards of Conduct, Anti-Trust Instructions, Confidentiality and Nondisclosure Agreement, Conflict of Interest Form, Exam Registration Form and Application for Recertification Form.
11. **Sustaining Sponsor Organization**: A Sustaining Sponsor Organization may be admitted to SMRPCO for a one (1) year period, by completing the required application form and paying the required fee for that period. Its representative may participate and vote on the SMRPCO Advisory Council, but is not a voting Certificant of SMRPCO unless he/she holds that designation in his/her own capacity. Rights and responsibilities of Sustaining Sponsor Organizations are provided in the SMRPCO Policies and Procedures Document.
12. **Volunteer Member**: A Certified Maintenance and Reliability Professional (CMRP) who, as a signatory to documents mentioned in the definition of “Signatory,” agrees to perform service

without compensation on the SMRPCO Board of Directors, Committee, Exam Team or other working group.

## **II. Candidates and Certificants**

### **A. Certification Examinations**

The Society for Maintenance and Reliability Professionals Certifying Organization offers the following credentials: Certified Maintenance and Reliability Professional (CMRP).

#### **a) Eligibility for Certification.**

- i There are no educational experiences or other requirements, other than completion of the application form, payment of applicable fees in advance and time since taking a previous certification exam for candidates who wish to take an examination for Certification of Maintenance and Reliability Professional – CMRP, and no conviction of a felony or other crime of moral turpitude under international, national, federal or state law in any matter related to the practice of or qualification for professional activity.
- ii Candidates who are unable to comply with the eligibility requirements will not be allowed to sit for the exam at that time.

#### **b) Examination Process Security Requirements**

- i SMRPCO includes a statement in the instructions preceding an exam which states that any violation of testing policies and procedures may result in dismissal from the exam venue, cancellation of exam scores and forfeiture of eligibility for exam fee refund.
- ii SMRPCO requires that identification presented at the test site contain a valid photograph and signature. Appropriate forms of identification may include the following:
- iii A passport, driver's license, other federal, national, provincial, territory or state government issued identification document or card.
- iv Candidates testing outside their country of citizenship must present a valid passport.
- v Candidates who are unable to comply with the identification requirements will not be allowed to sit for the exam at that time.

#### **c) Denial of Eligibility:**

- i. When any application for eligibility into a certification examination is denied, the applicant will be notified in writing (including e-mail), and the application fee, less a 10% processing fee, will be returned.

- iii. Denied applications may be appealed or resubmitted, with full fees, upon completion of all eligibility criteria.
- iv. Eligibility for entry into the certification examination for the maintenance and reliability (M & R) profession may be denied when:
  - Any part of the application is incomplete.
  - Any part of the application is illegible.
  - The application is not accompanied with the correct fees (in acceptable currency with an acceptable payment vehicle
  - An application and its supporting documentation do not adequately substantiate or properly demonstrate that the applicant has met the minimum eligibility criteria. Application must be organized according to the specified format.
- v. When an application for eligibility into a certification examination is denied, the applicant will be notified in writing (including e-mail) and the application fee, less a processing fee of 10%, will be returned.
- vi. Denied applications may be appealed or resubmitted with full fees upon completion of all eligibility criteria.

**d) Appeal of Denial of Eligibility**

- i. The SMRPCO grants certification status to individuals in the maintenance and reliability profession who complete the application procedure, ascribe to and abide by the SMRPCO Code of Ethics for candidates and certificants that is included as part of the application, successfully pass the applicable certification exam and pay all registration fees within established deadlines.
- ii. Applicants who have been denied eligibility may appeal the decision in the following manner:
  - The applicant submits a written (including e-mail) or faxed notice of appeal to the SMRPCO Staff who will forward it to the Certification Committee Chairman. The notice shall include the name, current address (including e-mail address), phone numbers and fax number (if applicable) of the applicant.
  - The applicant submits additional written, (including by e-mail) factual documentation to support their appeal with an explanation of why he/she believes the decision is erroneous. The applicant shall bear the burden of proving

the denial of eligibility was based on erroneous factual determination of the SMRPCO Staff.

- iii. An initial review of an appeal is conducted by the Certification Committee Chair to ensure the applicant has met the above conditions. If the Certification Committee Chair determines that the appeal meets the above conditions and the denial of eligibility was due to prior criminal history or misconduct, the case will be referred to the Executive Committee of SMRPCO. If the denial of eligibility was due to other circumstances the case will be referred to the Certification Committee. If the Certification Committee Chair determines that the appeal has not met the above conditions, the applicant will be notified that the appeal is disallowed and forward the record to the Executive Committee of SMRPCO for final determination.
- iv. The decision of the Executive Committee of SMRPCO is final and will be communicated to the Certification Committee Chair in writing. The Certification Committee Chair will notify the applicant of the decision in writing.
- v. There is no appeal allowed on the basis of incomplete applications.
- vi. This policy does not apply to certificants who have their certification or re-certification denied, suspended or revoked for fraud, misrepresentation, violation of testing procedures or other conduct in violation of the SMRPCO Code of Ethics, Standards of Conduct, Rules, Policies and Procedures.

**e) Testing in Languages Other than English**

SMRPCO offers the certification examination in English and Spanish. Other languages may be added. The use of translators during the examination will not be permitted.

**f) Policies for Applicants with English as a Second Language**

Candidates, whose primary language is not English, may use a strict translation dictionary developed for common use during a certification examination. Candidates must bring their own dictionary to the testing center. Any dictionary that has definitions, any written notes, or additional text will not be allowed. Electronic dictionaries are not allowed. Dictionaries will be inspected by the exam proctor and those violating this policy will be seized. Candidates who refuse to allow the proctor to inspect the dictionaries will not be admitted to the testing area with the dictionary and will be allowed to test without the dictionary at that time or to reschedule.

### **g) Examination Accommodations for Candidates with Physical Disabilities**

Special arrangements are made available to applicants with physical disabilities when requested in writing at the time the application is submitted or before, if the arrangements require longer time, subject to the following:

- If added expense is involved in accommodating the person with a physical disability, such expense (beyond requirements of law such as contained in the Americans with Disabilities Act) is borne by the candidate or the candidate's sponsor (e.g., employer or foundation providing support for persons with specific disabilities).
- If accommodation requires the presence of one or more persons to support the candidate because of the disability, they may not assist the candidate in any way in understanding exam content in such a way so as to give the candidate an unfair advantage over candidates without disabilities.
- Supporting personnel must sign a SMRPCO non-disclosure agreement and agree not to sit for the certification exam for that designation for a period of five (5) years.

### **h) Examination Statistics**

(i) Official statistics regarding any certification examination for the M & R profession, including all item performance data, individual and demographic group data will be considered confidential unless officially released by the Society for Maintenance and Reliability Professionals Certifying Organization. Candidates' scores will always remain confidential unless released with the express written permission of a candidate to an authorized agency in response to legal requirements.

(ii) Statistics will be stored at the SMRPCO office headquarters by the SMRPCO Certification Administrative Manager or other authorized staff member. The Exam Director will be provided with copies of statistics for review purposes and for purposes of reporting to the Certification Committee or Board of Directors. Exam Team and Certification Committee members will have access to such statistics as required to fulfill their duties, but shall keep them under strict control to prevent release to unauthorized persons. Statistics may be maintained by any authorized testing company for the duration of any contract with SMRPCO. In the event that a contract is not renewed, any and all copies of statistical information shall be returned to the SMRPCO offices. Statistics remain property of SMRPCO.

(iii) Yearly, SMRPCO will release, at a minimum, statistics regarding the total number of candidates tested and the percent of candidates passing. The Board will release additional information at its own discretion.

**i) Candidate Confidentiality**

A candidate's application and performance on any certification examination shall remain confidential unless otherwise stipulated by the examinee. Requests for score transfers to state licensing boards, regulatory commissions or government legal officials in pursuit of their duties and authority prescribed on law, must be made in writing (not by e-mail) by the candidate and submitted directly to SMRPCO. Scores will be sent directly to the state licensing/credentialing board or legal authority in the form of either a sealed transcript or a password protected electronic file.

**j) Release of Certificant Information**

(i) The Society for Maintenance and Reliability Professionals Certifying Organization maintains a registry of Certificants at its headquarters.

(ii) Unless specifically indicated that recognition is not desired by checking the appropriate block on the initial application for an examination or after becoming certified, notifying SMRPCO in writing (including e-mail) that recognition is desired, the Certificant's name, country and expiration date of certification will be listed on the SMRP/SMRPCO Website.

(iii) Upon written approval (including by e-mail) by a Certificant, the SMRPCO staff will release the name and country of certificants free of charge in response to a telephonic, faxed, or written (including e-mail) request from an officer, publicity chair, or media representative within the field of M & R Profession for purposes of acknowledgement and recognition.

(iv) Upon written approval (including by e-mail) by a Certificant, the SMRPCO staff will release the name, addresses, office telephone number, and the certification or recertification status of subject Certificant in good standing for the purpose of responding to referrals.

(v) SMRPCO will never loan, rent or sell candidate or Certificant information.

(vi) The names of failed candidates are confidential and will not be released.

(vii) Except as provided for by paragraph **II.A.f)** above, no score reports of any candidate or Certificant will be released to anyone outside of SMRPCO Staff, Volunteer or Special Needs Members or SMRPCO consultants who need the information to perform their authorized duties.

**k) Examination Score Reports**

The examination score reports will reflect only PASS or FAIL. Failing candidates and Certificants will be given diagnostic, non-numerical information indicating their overall performance for each section of the exam.

**l) Length of time to Schedule and Take the Examination**

Candidates must schedule and take an examination within six months of the date they make application and are made eligible to sit for it. Failure to do so within the time specified will result in forfeiture of all examination fees and the application will be considered void and returned to the candidate.

**m) Time Allowed to Sit for the Examination**

Candidates will be allowed a period of up to 2 hours to take the CMRP exam.

**n) Examination Security**

i. The Society for Maintenance and Reliability Professionals Certifying Organization maintains strict policies to insure the security of the examination.

- Candidates or Certificants who apply to take the test for reasons other than for initial certification or recertification, will be considered in violation of the SMRPCO Code of Ethics and will be subject to disciplinary procedures and/or legal action to mitigate the harm done to the certification process. Sanctions for Certificants could result in the termination of certification.

- Any individual who removes or attempts to remove exam materials from the testing site, including memorizing exam questions, will be prosecuted. Any Certificant who removes or attempts to remove examination materials, including memorizing exam questions, will be subject to disciplinary procedures in addition to legal action. Sanctions for Certificants could result in the removal of certification.

- Any unauthorized individual found in possession of exam materials will be prosecuted. Any unauthorized

Certificant who is found in possession of exam materials will be subject to disciplinary procedures in addition to legal action. Sanctions for Certificants could result in the removal of certification.

ii. Appropriate and specific test information will be provided to our stakeholders, if and when any are identified and verified to the satisfaction of the SMRPCO Board to have such an interest based on law of state, territory or country or Sustaining Sponsorship.

**o) Number of Times and Intervals Candidates May Take the Examination**

Candidates who fail a certification examination will be permitted to retake the examination as many times as necessary to achieve a passing score. Candidates who do not achieve a passing score will be required to wait for a six month period from the date of their last exam prior to retaking an exam. Application may be made in advance of the end of the time, up to 90 days as specified below.

**p) Appeals Concerning Items on Exams and Scoring of Exams**

i. Following completion of the examination and prior to receipt of the examination (Pass/Fail) results, candidates may comment in writing on any question(s) they believe contain errors in content. Comments will be forwarded to the Exam Director of SMRPCO. If the Exam Director judges that an item(s) should not be scored, all exams score-sheets that reflect lower than the passing score by an amount equal to the sum of the values of the item(s) being challenged shall be re-scored by hand. Candidates, whose status changes from fail to pass as a result of the re-scoring, shall be issued a certificate.

ii.. Candidates who fail the examination and believe this was due to an error in scoring may have their examination results hand scored by submitting a request in writing (including e-mail) to SMRPCO. Candidates have (7) days to request a hand score from the time of receipt of notification that they failed. Candidates may **not** have access to the answer key. Candidates, whose status changes as a result of hand scoring from fail to pass, shall be issued a certificate. All similarly affected candidates shall have their exams rescored and acted upon accordingly.

**B. Incomplete Candidate Applications**

If an applicant submits an incomplete application for a certification examination, the Society for Maintenance and Reliability Professionals Certifying Organization (SMRPCO) will retain the application for a period of 90 days from the date that SMRPCO provides the applicant with the “Incomplete Application Notice” described below. If the applicant fails to submit the required documentation

and/or appropriate payment(s) and therefore, does not complete his/her application, within the 90-day period, SMRPCO shall return all the applicant's application materials to the applicant and the application process shall be deemed to be terminated. At such time, the applicant's application fees and associated other application processing payment(s) shall be forfeited by the applicant.

During the 90-day period aforesaid, the applicant shall be permitted to cancel his/her application and receive a refund of the application fee. If the applicant wishes to extend the 90-day period in order to allow enough time to tender the requisite documentation and/or payment(s), then he/she must submit a written request to such effect to SMRPCO which request must be postmarked prior to the expiration of the aforesaid 90-day period. SMRPCO, in its sole discretion, shall consider all such requests. All decisions made by SMRPCO are final.

If the applicant's application is not complete, SMRPCO shall provide notifications to the applicant pursuant to the following notification schedule. The applicant solely shall be responsible for ensuring that his/her address in the SMRPCO database remains current and up-to-date.

**Notification Schedule:**

1st Letter or e-mail notification (Incomplete Application Notice) - SMRPCO shall deliver an Incomplete Application Notice to the applicant at the time the applicant's application is reviewed and denied, based, at least in part, on the failure of the applicant to submit the appropriate supporting documentation and/or application fee. The applicant will be informed of SMRPCO's policy that governs incomplete applications, as well as the fact that he/she has a period of 90 days to submit all of the requisite materials and/or necessary payment(s) in full.

2nd Letter or e-mail notification (Denial Notice) - SMRPCO shall deliver a Denial Notice to the applicant if the applicant has not timely completed and submitted the application and application fee to SMRPCO within the 90 day period specified. The Denial Notice shall be sent to the applicant subsequent to the expiration of the 90-day period. The applicant will be notified that his/her application has been denied and his/her application fee is forfeited. The applicant's application and associated materials, less the application fee, will accompany Denial Notice.

**C. Code of Ethics for Candidates and Certificants**

The Code of Ethics of the Society for Maintenance and Reliability Professionals Certifying Organization (SMRPCO) requires those who sit for the certification examination (Candidates), Certificants, Special Members, Staff, and Consultants to uphold professional standards that allow

for the proper discharge of their responsibilities to those served, protect the integrity of the profession, and safeguard the interest of individual clients.

**A.**

**All persons who sit for any SMRPCO examination shall:**

- Agree to maintain the confidentiality of the examination content and to never disclose examination content to others. Prohibited conduct includes disclosure of exam content, removal of exam materials from the examination room, copying by photography, use of audio recording equipment, or any other means that could be used to transfer the content to others.
- Attest to their identity as the registered examinee, and not represent anyone other than themselves in the taking of the exam.
- Attest that the work and selections made on the subject examination are theirs and theirs alone.

**Those examinees that pass a SMRPCO examination (hereafter known as Certificants):**

- Pledge to represent their profession ethically and honorably. Conduct by a Certificant that is detrimental to the SMRPCO Certification program may result in revocation of said Certification. Examples of detrimental conduct include but are not limited to dishonesty, misrepresentation of professional qualifications, and certain illegal acts leading to felony conviction. Certificants have the right to appeal revocations of Certification through due process that as is described in the SMRPCO Policies and Procedures Document.
- Represent their qualifications honestly, including their educational achievements and professional affiliations, and provide only those services which they are qualified to perform.
- Consistently maintain and improve professional knowledge and competence, striving for professional excellence through regular assessment of personal and professional strengths and weaknesses and through continued education training.
- Conduct their business and professional activities with honesty and integrity, and respect the inherent worth of all persons.
- Refuse to unjustly discriminate against clients.
- Safeguard the confidentiality of all client information, unless disclosure is required by law, court order, or is absolutely necessary for the protection of the public.
- Avoid any interest, activity or influence which might be in conflict with the Certificant's obligation to act in the best interests of the client or the profession.
- Refuse any gifts or benefits that is purely for personal gain and not for the good of the client which are intended to influence a referral or decision.
- Follow all policies, procedures, guidelines and requirements promulgated by the Society for Maintenance and Reliability Professionals Certifying Organization

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### **III. Subject Areas Addressed by the Certification Exam (Body of Knowledge)**

SMRP has developed a set of capabilities that are required for candidates to prove their mastery of in order to achieve the designation “Certified Maintenance and Reliability Professional” - (CMRP). The process by which this set of defined capabilities was developed required almost two years of effort and involved over four hundred individuals in the field of Maintenance and Reliability. They participated in focus groups, surveys and committee efforts. The process, called a **Job Task Analysis** was carried out largely by volunteer subject matter experts who were and are recognized in the profession. They were guided by paid consultants in Job Task Analysis and examination formulation and analysis who were well known in their field. The volunteers were supported by paid staff dedicated to producing the best possible end-product, the Body of Knowledge detailed below.

The Body of Knowledge is presented in two parts. **The first part presents high level titles** (in italics) **for each of five (5) different general achievement areas called Skill Sets – *Business and Management, Manufacturing Processes Reliability, Equipment Reliability, People Skills and Work Management*, numbered 1.0 through 5.0 respectively, and their related Functions** or typical tasks. **Functions** are outlined one level below the Skill Set by unique titles (also in italics) These are numbered, for example in the **Business and Management Skill Set 1.1, 1.2, 1.3, ...** The functions or tasks listed reflect what those performing the work of maintenance and reliability practitioners must master in order to be certified as professionals. In the Job Task Analysis effort involving nearly 400 individuals described above, **these titles (and nothing else)** were what participants were exposed to, for practical reasons related to survey length and participant fatigue.

As each **form** or **set of exam questions** is assembled for a certification exam by the SMRP Certifying Organization, great care is exercised to assure proportional coverage of all Skill Sets and some facet of all (or nearly all) **Functions** mentioned above. Thus, when candidates sit for an exam they can be assured that the set of questions included in the form they are using is balanced and comprehensive in terms of **Skill Sets** and **Functions** or typical tasks and/or knowledge areas upon which they are being examined.

**The second part of the Body of Knowledge (BoK) consists of additional explanatory information (not in italics)**, such as definitions and lists of possible areas or items upon which to gain experience and/or knowledge to prepare for the exam. This material was added by volunteer subject matter experts who served on the committee that developed the BoK, both before and after the Job Task Analysis survey, in order to:

- Clarify for volunteer committee members preparing the survey documents what each Skill Set and Function title meant so as to assure no gaps or redundancies in coverage,
- Provide a basis for judging whether any additions recommended by focus group and survey participants should be considered for inclusion in the explanations,

- Provide a guide for certification examination question developers as they formulate and submit items to be included in the examination bank for use on exams.
- Provide guidance for candidates for certification on material that might be included on the examination from any given function,

Thus the Body of Knowledge upon which candidates for the designation Certified Maintenance and Reliability Professionals (CMRP) are examined is presented starting below.

## ***1.0 Business and Management***

This area describes the skills used to translate an organization’s business goals into appropriate maintenance and reliability goals that support and contribute to the organization’s business results.

### ***1.1 Create Strategic Direction and Plan***

**Definition:** The functional head must create a vision and plan in order to get staff and management working towards the same goals. Maintenance and reliability leaders should be able to create and implement strategic plans that will meet the plant’s long-term business goals. Knowledge of how to gain upper management sponsorship and organizational support for the plan is key to its success. Leaders should also be able to draw on their experience and that of their staff to create a vision that enables attainment of goals and inspires the organization to achieve them. Key elements of the strategic plan include: establishing the business case; identifying current state, future state and gaps linked to key results areas; a progressive model for gap closure; a project plan with action items, timeline, resources and expected benefits; a process for management review and approval; communications to gain management and organizational support; and a review process for keeping the plan on track.

- 1.1.1 Identify sponsor(s) for change
- 1.1.2 Identify long-term business goals and what key results must be achieved
- 1.1.3 Identify today's performance and key results areas
- 1.1.4 Vision: What would be if we were good enough to achieve our goals?
- 1.1.5 List and group actions to close gap of vision with current status
- 1.1.6 Create agreement on maintenance and reliability improvement progression model
- 1.1.7 Create project description and prioritize
- 1.1.8 Create resource and benefits plan and key results areas
- 1.1.9 Develop implementation schedule
- 1.1.10 Achieve management review and approval
- 1.1.11 Communicate plan to gain “buy-in”
- 1.1.12 Revise plan on an annual basis
- 1.1.13 Present results to leadership periodically

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## 1.2 *Selling programs and change to stakeholders*

**Definition:** Resources will only be allocated when management understands the value, direction, and performance expectations of applying them. Maintenance and reliability leaders should have a clear vision of where they are going and how they plan to get there. They must be able to communicate it to those with a stake in the process to get them on board with the plan. This includes an understanding of the changes that will be involved for the organization, the people and the roles they will play, and the priorities for getting it done. Articulation of the benefits and the “what’s in it for me?” for all levels of the organization is key to success. Linking this to metrics will insure that goals are clear and that everyone knows “what success looks like”. Skill in positioning champions to lead the effort, obtaining management support for resources, and funding and enlisting customers and staff to support the plan is necessary.

- 1.2.1 Understand strategic direction
- 1.2.2 Identify who will be affected by changes, their role and motivation to change
- 1.2.3 Identify benefits and value for each stakeholder and how that is measured
- 1.2.4 Present value proposition to stakeholder groups and gain alignment
- 1.2.5 Agree on overall plant priorities for change
- 1.2.6 Gain agreement on path forward and plan
- 1.2.7 Identify accountabilities and champions for change
- 1.2.8 Gain resources to proceed
- 1.2.9 Staff time
- 1.2.10 Skills (internal and external)
- 1.2.11 Funding

## 1.3 *Create measurement and performance evaluation system*

**Definition:** Goals should be clear, measurable and established in a top-down manner: i.e., plant goals should drive business center goals that drive maintenance and reliability goals required to achieve them. Along with this, maintenance and reliability leaders should have knowledge of benchmarks for their industry to define long-term maintenance and reliability gaps for closure. An ability to identify the appropriate indicators to track is necessary for goal attainment and cultural change. For example, trending lagging indicators as bottom line measures of success and leading indicators as a means to effect performance improvement that impacts the bottom line. He/she must be able to define and implement methods to capture the required data, use appropriate indicators and identify when actions are required. Involvement of the organization in the development, implementation, and ownership of the systems is key to long-term success.

- 1.3.1 Identify plant goals and appropriate maintenance goals
- 1.3.2 Benchmark maintenance and reliability against industry leaders
- 1.3.3 Identify specific indicators to track:
  - 1.3.3.1 Plant level, production center, equipment
  - 1.3.3.2 Lagging indicators (cost, throughput, availability)
  - 1.3.3.3 Leading indicators (planned maintenance, %PM’s, schedule compliance)

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- 1.3.4 Identify means of capturing and reporting progress
  - 1.3.5 Create system to collect and report indicators
  - 1.3.6 Identify owners and accountability for measures and KPI's
  - 1.3.7 Review report and identify change actions

### **1.3.8 Manage risk**

**Definition:** Managing risk is a necessary task of today's maintenance and reliability professional. He/she should be familiar with various origins of risk for safety, environmental, maintenance, asset care, and capital investments and the financial, legal, and market impact they can have. To assess the risk and make decisions based on risk/benefit scenarios, one needs an understanding of the tools available for analyzing risk. One should be able to develop risk containment plans with compliance tracking methods to trigger variances and initiate follow-up response.

- 1.3.8. Identify sources of risk and maintenance responsibility for risk (statutory compliance and business) for:
  - 1.3.8.1 Hazardous materials handling
  - 1.3.8.2 Process safety management (where applicable)
  - 1.3.8.3 Environmental requirements
  - 1.3.8.4 Community emergency response
  - 1.3.8.5 Hazardous work safety management
  - 1.3.8.6 Engineering standards and codes
  - 1.3.8.7 Lifecycle costing
  - 1.3.8.8 Repair vs. replace decisions
  - 1.3.8.9 Spares levels
  - 1.3.8.10 Asset care level and frequency
- 1.3.9 Quantify risk where possible
- 1.3.10 Identify appropriate risk management approach and tools
  - 1.3.10.1 Financial impact
  - 1.3.10.2 Legal impact
  - 1.3.10.3 Market impact
  - 1.3.10.4 Tools: criticality assessment, fault tree analysis, planned work assessment, etc.
- 1.3.11 Identify responsibility for implementing risk containment approach
- 1.3.12 Identify compliance tracking method and business risk containment success
- 1.3.13 Implement solutions
- 1.3.14 Measure results and identify variances
- 1.3.15 Take appropriate change actions

### **1.4 Business Case Preparation**

**Definition:** A solid business case is required to get the funding, resources and support required. It provides a clear purpose (a demonstrated need) and benefits to be achieved. Components of a

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business plan include justification, current state, future state, gaps and an action plan to close them. Benefits should be tied to plant goals, measurable and expressed in financial terms whenever possible. Several potential solutions with risk/benefit scenarios and a recommended solution are desirable to provide options for the decision-makers.

- 1.4.1 Identify business need and direction
- 1.4.2 State the objective: what are we trying to achieve?
  - 1.4.2.1 Identify current status
  - 1.4.2.2 Production demand vs. capacity
  - 1.4.2.3 Operations cost opportunity
  - 1.4.2.4 Degrading capability
- 1.4.3 Identify expected/required state
  - 1.4.3.1 Production levels
  - 1.4.3.2 Costs
- 1.4.4 Identify method to close gap
- 1.4.5 Asset case strategy – component replacement
- 1.4.6 Capital strategy
- 1.4.7 Operational procedure
- 1.4.8 Quantify costs and benefits

### ***1.5 Communicate to stakeholders***

**Definition:** Maintenance leaders require the skills to communicate effectively to enlist support for improvement initiatives. This includes identifying the stakeholders, determining “what’s in it for them?” and communicating it to them in a manner to which they can best relate.

- 1.5.1 Identify stakeholders (to whom must we communicate?)
- 1.5.2 Identify what information the specific stakeholder requires (operational status, exceptions, improvement value)
- 1.5.3 Identify the source of information (e.g., key performance indicators)
- 1.5.4 Identify the method (system) of communication
- 1.5.5 Perform the communication task
- 1.5.6 Review effectiveness of communications and make action plans to change

### ***1.6 Plan and budget Resources***

**Definition:** Maintenance professionals need to be able to develop a plan and budget resources accordingly. A good plan draws on equipment and cost history, long-term asset care needs, and goals and uses them to develop an activity-based plan. This allows for creation of detailed plans for materials consumption, manpower and contract services that can be rolled up into a master plan. Load leveling can be utilized to provide the best balance of resources to minimize cost and disruption for the total plant. The appropriate accounting and CMMS systems should be utilized to monitor plan status and take actions in a timely manner.

- 1.6.1 Create annual production center staffing plan. By week for the year.
  - 1.6.1.1 Improvement efforts

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- 1.6.1.2 Scheduled maintenance (planned and preventive maintenance, outages, contractors, training)
  - 1.6.1.3 Corrective (estimate)
  - 1.6.1.4 Emergencies (estimate)
  - 1.6.2 Create annual materials plan.
    - 1.6.2.1 Scheduled maintenance (PMs, outages, overhauls)
    - 1.6.2.2 Estimates for corrective, emergencies (based on history)
  - 1.6.3 Load level unit resource requirements
  - 1.6.4 Roll up resource requirements to plant level.
  - 1.6.5 Load level resources at the plant level
  - 1.6.6 Contrast plan (proposed budget) with spending limits. Make adjustments as necessary.
  - 1.6.7 Make adjustments in maintenance management system to reflect load leveling
  - 1.6.8 Load budget into plant accounting system.
  - 1.6.9 Report resource consumption against budget. Take appropriate action.

### ***1.7 Maintenance/operations performance agreements / specifications***

**Definition:** It is important for operating, maintenance, and other involved disciplines to agree on the goals and the measures used to quantify them. Equally important is an understanding the roles everyone plays, and the responsibilities they have in contributing to goal accomplishment. Clarity around this can be accomplished by providing written definitions of roles and responsibilities and discussing to insure agreement by all. Routine review and discussion of progress will provide team commitment and allow for the periodic adjustments that may be required.

- 1.7.1 Operations & maintenance agree on performance specifications at the production center (department) level (e.g., uptime, breakdown response, planned downtime, cost, etc.)
- 1.7.2 Agree on roles and responsibilities for operators and maintainers with respect to the maintenance function.
- 1.7.3 Put the agreement in writing
- 1.7.4 Track performance
- 1.7.5 Meet periodically to review the performance. Make adjustments as necessary.

## ***2.0 Manufacturing Process Reliability***

This subject area relates maintenance and reliability activities to the manufacturing process of the organization to *ensure* that maintenance and reliability activities improve the manufacturing process.

### ***2.1 Maintain process and industry standards and specifications***

**Definition:** Maintenance professionals use standards and specifications as a way of translating the efforts of the reliability program into better performance of their company. One approach is to use comparative analysis between company results and the results of other companies,

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particularly if their performance is seen as setting a standard for performance. Gaps in performance of the reliability program must be identified, interpreted, and communicated to other areas of the company, e.g. financial, operational and other service departments. Plans to close the gaps are created, reviewed, and improved on a continuous basis as part of a "living program" approach to reliability.

- 2.1.1 Review and understand specifications and standards
- 2.1.2 Identify and analyze gaps between industry standards and company practices
- 2.1.3 Develop and implement plan to close gaps
- 2.1.4 Measure results and adjust plan

## **2.2 *Understand the manufacturing process***

**Definition:** Operations and maintenance and reliability resources should have the same understanding of the manufacturing process they deal with, differing only in the level of detail they require for their job function. Process flows must be known and documented in terms of inputs, outputs, resources, and constraints to the process. Controls are established to ensure the process is stable. Once stabilized, operations and maintenance people must not over-react to within-process variations, or conversely, not under-react to out-of-control process variations. Customer's needs are placed at the forefront of process and product designs, and equipment reliability is used to provide the subsequent stability and control that is required. Therefore reliability improvement projects are identified and used to provide added value to the customer.

- 2.2.1 Identify and understand what you make and how you make it
  - 2.2.1.1 Process training
  - 2.2.1.2 Interactions with process managers and operators
  - 2.2.1.3 Participate in Operations Process Improvement Teams
  - 2.2.1.4 Spend time with maintenance craftsmen
- 2.2.2 Identify process variability criteria and relationships affected by maintenance and reliability
  - 2.2.2.1 Statistical Process Control variances
  - 2.2.2.2 Meetings with operations organization
  - 2.2.2.3 Serve on problem-solving teams
- 2.2.3 Identify customer requirements
  - 2.2.3.1 Visit customers to identify reliability requirements
  - 2.2.3.2 Discuss customer reliability requirements with sales organization
- 2.2.4 Relate costs of best maintenance and reliability practices to customer value
  - 2.2.4.1 Cost of unreliability
  - 2.2.4.2 Benchmarking
- 2.2.5 Develop and implement plan to capture benefits identified

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## 2.3 *Manufacturing effectiveness techniques*

**Definition:** The maintenance and reliability and the operation and production resources must both have ways to measure their performance and progress against the business and manufacturing goals of the company. High-level key process indicators (KPIs) that align with the goals are co-developed by the people who own, operate, and maintain the process equipment. The responsibility for improving the effectiveness of the measures is shared by all parties, as evidenced by their participation in cross-functional activities that help achieve common goals.

- 2.3.1 Develop measures to relate equipment reliability to manufacturing process
  - 2.3.1.1 Overall Equipment Effectiveness
  - 2.3.1.2 Reject Rate
  - 2.3.1.3 Product quality
  - 2.3.1.4 Production rate improvement
- 2.3.2 Establish partnership between maintenance and operations for most effective asset management
  - 2.3.2.1 Total Productive Maintenance
  - 2.3.2.2 Create manufacturing teams
  - 2.3.2.3 Cross-functional, problem-solving, and process improvement teams

## 2.4 *Safety, Health, Environmental*

**Definition:** Occupational health and safety (H&S) and the environment must not be sacrificed to achieve manufacturing and production goals. The benefits of good H&S and environmental practices should be recognized for helping create a safer, happier work environment that nurtures improved job satisfaction. Given the degree of regulation that has been applied and people's sensitivities about these areas, it becomes vital to use pro-active programs to identify and eliminate any deviation from accepted environmental and H&S practices.

- 2.4.1.1 Identify benefits of good safety practices to bottom line
- 2.4.2 Identify specific Environmental, Safety, and Health (ESH) issues applicable to manufacturing process
  - 2.4.2.1 Process Hazard Analysis
  - 2.4.2.2 Job Safety Analysis
  - 2.4.2.3 Accident investigation (root cause failure analysis)
  - 2.4.2.4 Safety audits
- 2.4.3 Identify applicable regulatory issues/activities
  - 2.4.3.1 ESH-required inspections, tests, and PM activities
  - 2.4.3.2 Inspections of safety equipment (fire extinguishers, personal protective equipment inspections, eyewash/shower tests, etc.)
  - 2.4.3.3 Safety inspections of process and maintenance equipment (lifting equipment, ladders, safety valves)
  - 2.4.3.4 ESH activities associated with maintenance activities (lock-out/tag-out,

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confined space entry, hot work permits, waste disposal, personal protective equipment)

2.4.3.5 ESH specifications that regulate how maintenance, reliability, and design activities must be done (boiler maintenance regulations, water treatment process and equipment, permit-regulated operations)

2.4.4 Prevent acceptance of normalized deviation

2.4.4.1 Internal audits

2.4.4.2 Third party audits

## **2.5 *Manage effects of changes to processes and equipment***

**Definition:** It is possible for the people who administer reliability and maintenance programs to not achieve their goals because either: I) the process is intentionally changed without people evaluating the effect on equipment, or, II) equipment condition degrades over time to the point where it can no longer reliably meet the goals. To avoid these pitfalls, a formal change management process is needed to identify any significant changes to the process or equipment capability. Having identified any changes, a modification plan is developed to ensure that the process continues to have capable and reliable equipment assets.

2.4.1 Create process to identify when changes are being made (Management of Change process)

2.4.2 Apply analytical assessment process to identify effects of changes being made

2.4.2.1 Reliability Centered Maintenance Analysis

2.4.2.2 Failure Modes and Effects Analysis

2.4.3 Implement and manage changes in:

2.4.3.1 Policies

2.4.3.2 Procedures

2.4.3.3 Designs

2.4.3.4 Process/equipment modifications

## **3.0 *Equipment Reliability***

This subject area describes two kinds of activities that apply to the equipment and processes for which the maintenance and reliability professional is accountable. First are those activities used to assess the current capabilities of the equipment and processes in terms of their reliability, availability, maintainability, and criticality. Second are the activities used to select and apply the most appropriate maintenance practices, so that the equipment and processes continue to deliver their intended capabilities in the safest and most cost-effective manner.

### **3.1 *Determine equipment and process performance expectations from the business plan.***

**Definition:** Review the business plan and identify how its goals and expectations may affect implementation of the maintenance strategy, either directly or indirectly, by changing how equipment and process assets will be operated and maintained while meeting all business, licensing, environmental, safety and other regulatory goals and requirements.

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- 3.1.1 Review business goals to identify those that must be supported by maintenance and reliability strategies.
    - 3.1.1.1 Changes in sales goals
      - 3.1.1.1.1 Changes to production goals
      - 3.1.1.1.2 Changes in product mix sales goals
    - 3.1.1.2 Changes to production processes
      - 3.1.1.2.1 New equipment
      - 3.1.1.2.2 New uses for existing equipment
    - 3.1.1.3 Changes to staffing levels
    - 3.1.1.4 Changes to budgets/capital spending
  - 3.1.2 Calculate required equipment/process availability, based on production requirements to meet business goals including effects of changeovers to different products.
  - 3.1.3 Establish equipment maintenance plan resources budget
    - 3.1.3.1 Labor costs
    - 3.1.3.2 Cost of spare parts/replacement parts
    - 3.1.3.3 Cost of external contractors and services
    - 3.1.3.4 Cost of product replacement or service interruption due to equipment maintenance or failures

### **3.2**      *Establish current performance levels and analyze gaps*

**Definition:** Determine the current capabilities of the production equipment to meet the expectations of the business plan. Identify and quantify gaps between capabilities and expectations.

- 3.2.1 Prioritize equipment assets and processes to assure that maintenance and reliability resources are appropriately allocated
  - 3.2.1.1 Criticality
  - 3.2.1.2 Capacity
  - 3.2.1.3 Cost
- 3.2.2 Select and apply appropriate metrics to assess current condition and capabilities of equipment assets and production processes.
  - 3.2.2.1 MTBF/Failure rate/MTTR/Repair rate
  - 3.2.2.2 Maintenance cost/unit of production
  - 3.2.2.3 Equipment availability
  - 3.2.2.4 Process availability or system availability
  - 3.2.2.5 Scrap rate
  - 3.2.2.6 Production delays
  - 3.2.2.7 Total maintenance cost as percentage of asset
  - 3.2.2.8 Replacement value
  - 3.2.2.9 Delay rate
  - 3.2.2.10 Percent planned or unplanned maintenance
  - 3.2.2.11 Maintainability
- 3.2.3 For existing equipment and processes, review results of performance assessment to identify opportunities for improvement and potential performance shortfalls.

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- 3.2.3.1 Changes in operating conditions that may change maintenance requirements
  - 3.2.3.2 Changes in performance expectations
  - 3.2.3.3 Inadequacies of existing maintenance practices
  - 3.2.3.4 Newly identified maintenance requirements discovered through failure investigation
  - 3.2.3.5 Opportunities to apply more sophisticated new maintenance technologies
  - 3.2.3.6 Chronic problem equipment
  - 3.2.3.7 Root Cause Failure Analyses of significant past failures
  - 3.2.3.8 Pareto Analysis
  - 3.2.3.9 Bottleneck Analysis
  - 3.2.3.10 Weibull (distribution) Analysis
  - 3.2.4 Identify anticipated maintenance requirements for new equipment

### **3.3      *Establish a maintenance strategy to assure performance***

**Definition:** The equipment maintenance plan provides the following functions: 1) It describes the specific maintenance practices to be applied to assure the day-to-day reliability of the equipment being maintained. 2) It supports and helps achieve the company’s stated business goals. 3) It supports and helps implement the vision of the corporate maintenance strategy (also see Section 1.0, Business and Management).

- 3.3.1      Establish performance improvement targets
  - 3.3.1.1      Process availability improvement
  - 3.3.1.2      Reliability analysis and reliability growth
  - 3.3.1.3      Maintenance cost reduction and overall maintenance performance
  - 3.3.1.4      % Reduction in Unplanned Maintenance
  - 3.3.1.5      Overall Equipment Effectiveness
  - 3.3.1.6      Process capability improvement
  - 3.3.1.7      Percent planned and scheduled maintenance
  - 3.3.1.8      Return on Net Assets (RONA)
- 3.3.2      Select activities (tactics) to meet targets and close gaps
  - 3.3.2.1      For equipment and processes where maintenance issues and requirements are clearly understood, select and apply appropriate maintenance practices:
    - 3.3.2.1.1      Restoration/replacement activities
    - 3.3.2.1.2      Condition-based maintenance activities
    - 3.3.2.1.3      Failure-finding tasks
  - 3.3.2.2      For equipment or processes where maintenance costs are high, where reliability is low, or where chronic problems exist, perform additional analysis to identify appropriate maintenance practices.
    - 3.3.2.2.1      Root Cause Failure Analysis
    - 3.3.2.2.2      Failure Modes and Effects Analysis
    - 3.3.2.2.3      Reliability-centered maintenance analysis
  - 3.3.2.3      For planned new equipment purchases and installations where no maintenance history exists, apply M&R “best practices” to assure maximum reliability
    - 3.3.2.3.1      During initial design

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- 3.3.2.3.1.1 To assure ease of maintenance
  - 3.3.2.3.1.2 To maximize process and component reliability
  - 3.3.2.3.1.3 Life-cycle Cost Analysis
  - 3.3.2.3.1.4 Design for maintainability
  - 3.3.2.3.2 During procurement
    - 3.3.2.3.2.1 To minimize life-cycle cost
    - 3.3.2.3.2.2 To assure most reliable materials of construction are used
    - 3.3.2.3.2.3 Purchasing specifications
    - 3.3.2.3.2.4 Qualification of vendors
  - 3.3.2.3.3 During installation or acquisition of equipment with known or unknown history
    - 3.3.2.3.3.1 Reliability-centered Maintenance Analysis
    - 3.3.2.3.3.2 Failure Modes and Effects Analysis
    - 3.3.2.3.3.3 Precision installation
    - 3.3.2.3.3.4 Performance tests
  - 3.3.2.3.4 During startup and operation
    - 3.3.2.3.4.1 Use detailed commissioning, startup and operating procedures
    - 3.3.2.3.4.2 Institute operator basis care/PM (TPM) and tour requirements
    - 3.3.2.3.4.3 Conduct operator condition monitoring of both process and equipment
    - 3.3.2.3.4.4 Sustain team focus on excellence including during shift hand-over between teams
    - 3.3.2.3.4.5 Emphasize teamwork between operations, maintenance and engineering
  - 3.3.2.3.5 During maintenance activities throughout the life cycle
    - 3.3.2.3.5.1 Reliability-centered maintenance analysis living program
    - 3.3.2.3.5.2 Emphasize use of detailed procedures sustained by a continuous improvement program

### **3.4** *Cost-justify (budget) tactics selected for implementation*

**Definition:** Prepare maintenance and reliability budget to help manage costs to implement the maintenance and reliability strategy. Prepare business cases as required to justify maintenance and reliability efforts to correct exceptional equipment deficiencies.

- 3.4.1 Establish cost/manpower resource requirements to implement maintenance tactics selected
  - 3.4.1.1 Determine cost (or potential cost) of unreliability for critical components
    - 3.4.1.1.1 Repair cost
    - 3.4.1.1.2 Cost to repair collateral damage
    - 3.4.1.1.3 Lost opportunity cost
    - 3.4.1.1.4 Product replacement cost
  - 3.4.1.2 Allocate resources to reduce cost of unreliability
- 3.4.2 Prioritize and allocate costs as required to meet business plan

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### 3.5 *Execute a maintenance strategy (See Work Management, section 5.0)*

**Definition:** Apply the Work Management Skill to execute the Maintenance and Reliability strategy.

- 3.5.1 Allocate resources to carry out each element of the strategy
- 3.5.2 Ensure each strategic action is brought to closure

### 3.6 *Review performance and adjust maintenance strategy*

**Definition:** Continually review maintenance and reliability key performance indicators to track effectiveness of the maintenance and reliability strategy. Adjust strategy as required when key performance indicator deviations begin to occur.

- 3.6.1 Identify and assess gaps between actual performance and improvement targets
  - 3.6.1.1 Review planned maintenance activities
    - 3.6.1.1.1 Are maintenance intervals correct?
    - 3.6.1.1.2 Do procedures assure proper execution of the maintenance activity?
    - 3.6.1.1.3 Do scheduled inspections and tests identify the faults they are intended to find?
    - 3.6.1.1.4 Are maintenance activities still cost-effective?
    - 3.6.1.1.5 Are PM's optimized in all respects?
  - 3.6.1.2 Review Predictive Maintenance (PdM) programs
    - 3.6.1.2.1 Are PdM and condition monitoring technologies detecting known failure modes and have 'saved' justified Predictive Maintenance costs?
    - 3.6.1.2.2 Are there new or additional technologies to consider adding to the Predictive Maintenance program?
      - 3.6.1.2.2.1 Vibration analysis
      - 3.6.1.2.2.2 Shock Pulse analysis
      - 3.6.1.2.2.3 Ultrasonic and acoustic analysis
      - 3.6.1.2.2.4 Lubricant quality analysis
      - 3.6.1.2.2.5 Wear Particle analysis
      - 3.6.1.2.2.6 Temperature measurement and infrared analysis (thermography)
      - 3.6.1.2.2.7 Eddy current analysis
      - 3.6.1.2.2.8 Electrical circuit analysis
      - 3.6.1.2.2.9 Transformer condition analysis
    - 3.6.1.2.3 Are operators applying process trend and control chart and "look, listen, feel, smell" routinely?
    - 3.6.1.2.4 Is PdM and process condition monitoring fully integrated with planning and scheduling?
- 3.6.2 Identify best practices and new technologies which might improve equipment process reliability
  - 3.6.2.1 Benchmarking
  - 3.6.2.2 Trade associations and professional societies
  - 3.6.2.3 Industry standards and specifications

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- 3.6.3 Audit performance of and compliance with M&R initiatives and programs.
  - 3.6.4 Adjust targets or performance as required to close performance gaps
  - 3.6.5 Analyze system or equipment failures and assure that maintenance strategy addresses potential future failures as required (Root Cause Failure Analysis - RCFA), Failure Modes and Effects Analysis - FMEA, etc.)
    - 3.6.5.1 Establish a process to qualify high-impact failures for failure analysis
    - 3.6.5.2 Establish a process to transfer failure analysis findings back into the maintenance strategy

## **4.0 People Skills**

This inventory describes processes for assuring that the maintenance and reliability staff is the most qualified and best assigned to achieve the maintenance and reliability organization goals.

### **4.1 Assess organizational competence and direction**

**Definition:** The people responsible for reliability at the management level must constantly scan their environment for trends, issues and opportunities that might impact the reliability program. This is essential for keeping it relevant and supportive of the business goals of the company. Keeping any new information in mind, the ability of the maintenance and reliability program to support business goals is evaluated and changes made according to any new requirements. Strategic and tactical plans are developed and used in tandem with a communication plan to ensure the changes are understood and accepted at all levels of the maintenance and reliability workforce.

- 4.1.1 Identify business goals, direction, plans, and drivers
  - 4.1.1.1 Strategic direction
  - 4.1.1.2 Capital upgrades
  - 4.1.1.3 Markets
  - 4.1.1.4 Acquisitions and plant expansions/contractions
  - 4.1.1.5 Outsourcing
  - 4.1.1.6 Organizational changes
  - 4.1.1.7 Specific cost and volume goals
  - 4.1.1.8 Safety and environmental requirements
- 4.1.2 Identify constraints
  - 4.1.2.1 Culture
  - 4.1.2.2 People
  - 4.1.2.3 Resources
  - 4.1.2.4 Contracts
    - 4.1.2.4.1 Organized Labor
    - 4.1.2.4.2 Customer performance
  - 4.1.2.5 Asset condition
  - 4.1.2.6 Existing policies, practices, processes
- 4.1.3 Assess and document current structure, skills, and effectiveness
  - 4.1.3.1 Workforce demographics
  - 4.1.3.2 Skills certifications/documentation/training
  - 4.1.3.3 Key performance indicators  $\text{D}$  rework, job estimate variation

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- 4.1.3.4 Schedule compliance
  - 4.1.4 Develop consensus with facility leadership team

## **4.2 *Develop the maintenance and reliability organization structure***

**Definition:** The reliability professional must understand the importance of an enabling organizational structure, without which the best intended maintenance and reliability efforts may not succeed. Organizational development aims to take the "as-is" structure of the company and move it forward into the desired "to-be" state. If maintenance and reliability is not included in the planning and transition stages of any re-organization effort, a good maintenance and reliability program may fall by the wayside, or an improvement program may never get off the ground.

- 4.2.1 Define future state for organization
  - 4.2.1.1 To correct deficiencies
  - 4.2.1.2 To assure highest priority work is done
  - 4.2.1.3 To enable change and improvement
  - 4.2.1.4 To maximize flexibility of workforce
  - 4.2.1.5 To achieve common goals
- 4.2.2 Design organizational structure to achieve future state
  - 4.2.2.1 Reporting structure
  - 4.2.2.2 Define roles and relations to other functions
- 4.2.3 Define job objectives, responsibilities, and performance criteria
  - 4.2.3.1 Job descriptions
  - 4.2.3.2 Assess competence to fill jobs
  - 4.2.3.3 Document gaps
- 4.2.4 Assign staff and communicate organization plan
  - 4.2.4.1 Develop training materials
  - 4.2.4.2 Train and present (inside and outside the maintenance and reliability organization)
  - 4.2.4.3 Communicate expectations
- 4.2.5 Evaluate performance of organizational structure and take corrective action

## **4.3 *Develop the maintenance and reliability staff***

**Definition:** The people resources assigned to the reliability program need to be evaluated and developed according to their skills inventories and training needs evaluations. Based on these, personal development plans are used to transfer the required skills that will provide the required level of performance on the job. An "evergreening" process is desirable to help keep the workforce skills current with new developments in equipment technology and manufacturing processes. Using the strategy, plan and goals above, determine skills requirements over the short and long term, review current skills and identify skills gaps.

- 4.3.1 Develop skills acquisition and development plan
  - 4.3.1.1 Plan for existing employees (movement in and out of organization)
  - 4.3.1.2 Requirements for new hires
  - 4.3.1.3 Requirements for contractors
- 4.3.2 Train and certify in skills and track development
- 4.3.3 Setup and record skills database

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- 4.3.4 Measure job performance
    - 4.3.4.1 Supervisor and peer evaluation
    - 4.3.4.2 Craftsman productivity
    - 4.3.4.3 Annual goal achievement
    - 4.3.4.4 Individual goals
    - 4.3.4.5 Unit goals
  - 4.3.5 Provide feedback and counseling
    - 4.3.5.1 Staff
    - 4.3.5.2 Recruiter/HR
    - 4.3.5.3 Contractor
  - 4.3.6 Design career development and succession plans

#### **4.4** *Communicate maintenance and reliability to the organization*

**Definition:** Reliability and maintenance professionals need to use a good communication plan to avoid many of the pitfalls associated with their improvement and sustaining efforts. Providing people at all levels of the organization with the appropriate news about program changes or successes will foster acceptance and increase the demand for better reliability programs. Conveying the right message at the right time help maintenance and reliability resources maintain a good profile that is relevant to the company.

- 4.4.1 Identify information exchange requirements
  - 4.4.1.1 Who needs what information within maintenance and reliability organization
  - 4.4.1.2 Who needs what information outside maintenance and reliability organization
- 4.4.2 Identify methods to measure if communications was successful
  - 4.4.2.1 Surveys: progress, measures and comprehension
  - 4.4.2.2 Management by walking around (MBWA)
- 4.4.3 Establish decision communication vehicles
  - 4.4.3.1 E-mail
  - 4.4.3.2 Presentations
  - 4.4.3.3 Reports
  - 4.4.3.4 Bulletin boards
  - 4.4.3.5 Memos
  - 4.4.3.6 Intranet
- 4.4.4 Develop implementation plan
  - 4.4.4.1 Implement communication plan
  - 4.4.4.2 Measure results and make adjustments

### **5.0 Work Management**

This subject area focuses on the skills used to get the maintenance and reliability work done. It includes scheduling and planning activities, quality assurance of maintenance activities, stores and inventory management.

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## 5.1 *Comprehensive work identification*

**Definition:** It is important for those who identify needed maintenance work to understand the different types of actions that can be taken and when they should be applied from a technical standpoint. Of equal importance is the ability to assess the business justification for the maintenance plan and to develop the needed data support systems for it. The ability to manage the work, to keep the appropriate backlog, and to minimize overdue work must also be evident.

- 5.1.1 Applies life cycle or asset management tools/techniques
  - 5.1.1.1 Establishes critical equipment list
  - 5.1.1.2 Establishes equipment data base in CMMS
  - 5.1.1.3 Establishes hierarchy of equipment and systems
  - 5.1.1.4 Develops and implements planned and predictive maintenance strategy using tools such as RCM
- 5.1.2 Differentiates types of work accurately
  - 5.1.2.1 Failure finding
  - 5.1.2.2 Preventive
  - 5.1.2.3 Predictive / Condition based
  - 5.1.2.4 Corrective
  - 5.1.2.5 Small projects - Maintenance & Repair
  - 5.1.2.6 Major shutdowns
  - 5.1.2.7 Operational support
- 5.1.3 Applies backlog management techniques
- 5.1.4 Monitors overdue jobs

## 5.2 *Plant-wide formal prioritization system*

**Definition:** The maintenance professional needs to be able to develop a logical and easily followed system of prioritization for the work of a plant-wide work group with multiple skill sets. The prioritization system needs to address all the factors critical to both business success and the maintenance function.

- 5.2.1 Applies factors used for prioritization
  - 5.2.1.1 Equipment / system criticality
  - 5.2.1.2 Production needs
  - 5.2.1.3 Safety or environmental impact
  - 5.2.1.4 Manpower requirements for major shutdowns or emergencies
- 5.2.2 Develops and implements prioritization system that defines and assigns time factors for completion of work

## 5.3 *Effective work planning prior to scheduling*

**Definition:** The proper understanding of the planning process is critical to those managing the maintenance function. The maintenance professional needs to be able to articulate the business value derived from the planning process. Planning is the key to increased efficiency of the maintenance work force, and those who manage it must know the steps involved in creating an effective and efficient plan. They must also know how to utilize the systems that support the

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planning process. The differences between day-to-day maintenance planning and the planning of a major turnaround need to be understood.

- 5.3.1 Applies the elements of job planning
  - 5.3.1.1 Job review and consulting with appropriate people
  - 5.3.1.2 Using the CMMS for planning
  - 5.3.1.3 Specifying and providing materials
  - 5.3.1.4 Sequence of work
  - 5.3.1.5 Special tools, equipment or safety needs
  - 5.3.1.6 Safety, Health, and Environmental concerns
  - 5.3.1.7 Special permits
  - 5.3.1.8 Job estimating
  - 5.3.1.9 Job monitoring
  - 5.3.1.10 People resource requirements
  - 5.3.1.11 Contractor interface and requirements
  - 5.3.1.12 Requirements for work order close out
- 5.3.2 Adds business value (reduced costs) through properly planned and scheduled work
  - 5.3.2.1 Turnaround (shutdown) planning
  - 5.3.2.2 Creating and structuring the turnaround team
  - 5.3.2.3 Critical path methodology
  - 5.3.2.4 Use of a computerized shutdown planning tool
  - 5.3.2.5 Sets proper lead times
  - 5.3.2.6 Shutdown time minimization techniques
  - 5.3.2.7 Turnaround period extension techniques
- 5.3.3 Establishes and applies metrics to analyze the performance of planning and scheduling

#### **5.4      *Effective, cooperative work scheduling and backlog management***

**Definition:** The maintenance professional needs to understand the key success factors to proper work scheduling. The multiple needs from plant groups and the business need to be considered in the scheduling process. An understanding of how to balance all factors and create a logical and achievable schedule is required. The systems that are connected to and support the scheduling process need to be well understood.

- 5.4.1 Applies a comprehensive scheduling process
  - 5.4.1.1 Daily, weekly, monthly schedules
  - 5.4.1.2 Coordinated with operations needs
  - 5.4.1.3 Manpower balancing
  - 5.4.1.4 Materials expediting process
  - 5.4.1.5 Conflict resolution
  - 5.4.1.6 Be sure job is “ready to schedule”
- 5.4.2 Arrange for permits & special requirements and lock & tag requirements
- 5.4.3 Controls the impact on productivity of schedule break-ins by restricting unscheduled work

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- 5.4.4 Establish metrics for performance

## **5.5 *Effective resource management (people, materials, financial)***

**Definition:** The methods and best practices for effective use of maintenance resources need to be clearly understood. The maintenance professional needs to understand the process of keeping the workforce skill inventory abreast of the needs of the maintenance plan. The systems needed to properly support the management of the critical resources of maintenance should be well understood. The criteria for the appropriate use of the various methods of making spare parts available to the maintenance function, along with the values and risks associated with each, need to be known. Methods for sound cost management of the maintenance function and how the value of the work performed impacts the business financial metrics needs to be understood. The maintenance professional needs to be able to select the most appropriate metrics to support the needs of the business and guide the workforce to higher levels of performance.

- 5.5.1 Applies best practice concepts of people management
  - 5.5.1.1 Effective use of mechanics time
  - 5.5.1.2 Roles of planner, coordinator, supervisor
  - 5.5.1.3 Auditing and benchmarking performance
  - 5.5.1.4 Establishing the proper skill mix
- 5.5.2 Establishes training plans and skills evaluation
  - 5.5.2.1 Up-to-date maintenance procedures
  - 5.5.2.2 Task - skill analysis
  - 5.5.2.3 Developing individual training requirements
  - 5.5.2.4 Creating a site or crew training plan
- 5.5.3 Applies best practice concepts of materials management
  - 5.5.3.1 Applies spare parts management models
  - 5.5.3.2 Assures use of the CMMS for equipment /parts bills of materials
  - 5.5.3.3 Ensures complete and correct bill of materials for critical equipment
  - 5.5.3.4 Stores/sub-stores inventory control
  - 5.5.3.5 Implements use of integrated suppliers and consignment parts
  - 5.5.3.6 Establishes quality assurance program for spare parts
  - 5.5.3.7 Develops spare parts kitting strategy for planned jobs
  - 5.5.3.8 Ensures optimum stock availability and cost (free-issue vs. controlled issue)
  - 5.5.3.9 Develops and implements spare parts justification methods
  - 5.5.3.10 Applies a holistic, work-process view of materials (right part at right place at right time)
  - 5.5.3.11 Analyzes life cycle costs and adjusts materials management strategy
  - 5.5.3.12 Analyses purchase cost vs. maintenance, lost opportunity and operating costs
- 5.5.4 Applies best practice concepts of maintenance costs management
  - 5.5.4.1 Ensures an accurate cost accounting system
  - 5.5.4.2 Develops comprehensive cost reporting and monitoring monthly
- 5.5.5 Analyzes how performance affects costs and performs “look-backs” to adjust strategy

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- 5.5.6 Analyzes the effect of maintenance and reliability costs on business metrics such as RONA (return on net assets), EVA(economic value added), PIT, etc. 5.5.6.1 Maintenance budgeting – forecasting and zero based budgeting
    - 5.5.6.2 Applies standards for effective use of contractors
  - 5.5.7 Establishes contracting principles
    - 5.5.7.1 Best practice contractor management techniques
  - 5.5.8 Establishes metrics of performance

## **5.6 Document work execution and update records / history**

**Definition:** Maintenance professionals must demonstrate their ability to create, update and manage work orders in a way that insures that those who will do the work understand what needs to be done, how long it should take, what safety precautions need to be taken, and the materials they will need. Also, they must assure that valuable historical data is kept, and this data can be used to guide improvements. The proper methods for cost estimation and the use of the appropriate work order type for the situation should be known.

- 5.6.1 Applies the basic elements of an excellent work order system
  - 5.6.1.1 Writing quality work orders
  - 5.6.1.2 Preparing accurate estimates of labor and materials requirements
  - 5.6.1.3 Applies use of blanket orders appropriately
  - 5.6.1.4 Develops and applies visual maintenance systems
- 5.6.2 Ensures good work order history records
  - 5.6.2.1 Ensures closing out work orders in timely manner
  - 5.6.2.2 Ensures backlogs are current
  - 5.6.2.3 Makes modifications to the job plan, such as adjustments to estimates
  - 5.6.2.4 Ensures as found and repair histories are kept and are accurate
  - 5.6.2.5 Establishes data entry requirements for useful reporting
- 5.6.3 Utilizes labor effectively
  - 5.6.3.1 Conducts time and motion analyses and studies
- 5.6.4 Ensures task staffing
- 5.6.5 Applies best practice work assignment processes
  - 5.6.6.1 Controls unplanned work and emergency work
  - 5.6.6.2 Ensures safety aspects are considered

## **5.7 Equipment history review and failure identification**

**Definition:** The proper methods for assessing both equipment reliability and resource effectiveness must be understood. The maintenance professional needs to know the methods for assessing where to most effectively apply their resources so as to bring the most value to the business they support. The different methodologies for finding the sources of defects, the root causes of failure, and how to bring about the needed changes to prevent reoccurrence needs to be known. A reliability and defect elimination mindset needs to be evident.

- 5.7.1 Applies techniques for analyzing equipment history
  - 5.7.1.1 Calculates mean time between failures (MTBF)
  - 5.7.1.2 Calculates mean time to repair (MTTR)

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- 5.7.1.3 Weibull analysis
  - 5.7.1.4 Identifies costliest pieces of equipment (Pareto charts - cost of lost production, plus maintenance cost)
  - 5.7.1.5 Analyzes equipment effects on production capability
  - 5.7.2 Learns from failures, applies root cause analysis
  - 5.7.3 Applies a continuous defect elimination mindset
    - 5.7.3.1 Analyzes and understands sources of defects
    - 5.7.3.2 Identifies chronic versus sporadic failures and how they differ
    - 5.7.3.3 Develops methods for preserving and collecting failure evidence
  - 5.7.4 Uses multi-functional teams for failure analysis and problem solving
    - 5.7.4.1 Identifies failure patterns
  - 5.7.5 Applies CMMS reporting capabilities to support failure identification

## **5.8**    *Effective performance measures and follow-up*

**Definition:** The understanding of maintenance performance metrics and how to apply them needs to be demonstrated. The ability to identify and use complementary metrics to give a well-rounded assessment of performance and to support the needs of the business should be evident.

- 5.8.1 Applies frequently used performance metrics
  - 5.8.1.1 Percent planned work
  - 5.8.1.2 Percent schedule compliance
  - 5.8.1.3 Backlog hours
  - 5.8.1.4 PM completion versus scheduled
  - 5.8.1.5 Uptime

## **5.9**    *Capital project planning*

**Definition:** The maintenance professional understands all the steps required to plan and implement a capital project. The requirements of each step need to be known. The ability to use tools and techniques critical to the success of a project planning process needs to be evident.

- 5.9.1 Develops scope of work
- 5.9.2 Estimates cost and timing
- 5.9.3 Creates credible justification
- 5.9.4 Establishes design requirements
- 5.9.5 Builds reliability in up-front by design that applies Life Cycle Cost and RCM/FMEA principles
- 5.9.6 Recruits project team members from operations and maintenance
- 5.9.7 Applies best practice use of engineering and construction contractors
- 5.9.8 Estimates of construction time
- 5.9.9 Effectively manages contractors
- 5.9.10 Applies critical path scheduling tools
  - 5.9.10.1 PERT diagrams
  - 5.9.10.2 Software such as Timeline, Microsoft Project, etc

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## 5.10 *Effective use of information technologies (CMMS, etc)*

**Definition:** The maintenance professional needs the ability to use a wide variety of computerized systems for the management of the information used in the management of the maintenance function. An understanding of the functionality of a Computerized Maintenance Management System as well as systems used to transfer or share data and documents between both people and various databases needs to be evident. The ability to manipulate data into information on a host of computerized systems commonly used by maintenance needs to be demonstrated. An understanding of when and how to most appropriately use computerized tools to manage maintenance work, assess the health of equipment, and to guide improvement efforts should be part of the maintenance professional's abilities.

- 5.10.1 Applies technologies for documents transfer and record keeping
  - 5.10.1.1 Examples: Prism, Mockingbird, etc.
  - 5.10.1.2 Examples: Lotus Notes, Microsoft Office, etc.
- 5.10.2 Applies basic functions of a CMMS
  - 5.10.2.1 Equipment records / bill of materials
  - 5.10.2.2 Work order control system
  - 5.10.2.3 Planning and scheduling work
  - 5.10.2.4 Equipment history records (inspection, failure and cost data)
  - 5.10.2.5 Process Safety Management records
  - 5.10.2.6 Interfaces to other systems like accounting, personnel, sourcing
  - 5.10.2.7 Reporting capabilities (converting data to information)
- 5.10.3 Applies predictive maintenance information technology tools, such as vibration monitoring
  - 5.10.3.1 Discriminates appropriate level of data to include
  - 5.10.3.2 Critically evaluates required data entry to ensure meaningful information/reporting output

## **IV. Re-certification**

### **A. Re-certification Purpose, Philosophy and Requirements**

Re-certification assures the public that the Certificant is adhering to the SMRPCO Code of Ethics, and Policies and Procedures concerning re-certification.

#### **a) Philosophy of the CMRP Recertification Program**

(i) Re-certification is defined as a process designed to facilitate continued competence including ethics and practice in the M & R profession through participation in a learning process that enhances the Certificant's knowledge, skills and abilities.

(ii) Upholding high standards of ethical and generally accepted maintenance and reliability practices is the foundation of certification.

(iii) Certificants need to continue to learn throughout their professional lives to remain up-to-date in their areas of work.

(iv) Maintaining "hands-on" experience in the M & R profession is essential to maintaining skills.

(v) Learning occurs in multiple ways beyond the formal educational setting and includes learning through professional and life experiences.

(vi) Self-assessment can be a valuable strategy for identifying some of the Certificant's needs, but is not mandatory.

#### **b) Notification and Certificant Responsibility**

Each Certificant will be notified by mail or e-mail approximately one year, and again at six months prior to the certification expiration of the need to recertify. It is the responsibility of each Certificant to notify the SMRPCO office of address and name changes in writing to be aware of the expiration date of their certification, and to know when to apply for recertification. A copy of the current verification form may be downloaded from the SMRP/SMRPCO website, [www.SMRP.org](http://www.SMRP.org) at any time following initial certification. A copy is also attached as an Appendix to this guide.

#### **c) Requirements for Recertification**

(i) Certificants must meet recertification requirements during the current three (3) year certification cycle to retain certified status for each subsequent three (3) year cycle. This requires ongoing personal and professional development in the area of M & R profession. The process is also designed to facilitate and recognize contributions to the profession. Recertification candidates must strictly comply with all requirements contained in the recertification

(ii) Individuals can recertify under the recertification program which requires 50 recertification credits (e.g., 1 hour = 1 credit) from a combination 2 or more activities (Options) described below.

- Option 1 – Continuing professional education in areas relevant to the five (5) skill sets described in the Body of Knowledge (BoK) – Actual hours spent in the classroom are counted.
- Option 2 - Complete educational workshops or seminars relevant to subject areas in the BoK – Actual hours spent in the workshop or seminar
- Option 3 – Participate as an active member of an SMRP or SMRPCO Board or Committee – Actual hours spent in such meeting activity.
- Option 4 – Attend annual/executive/chapter meetings at organizations relevant to subject areas of the BoK – (e.g., SMRP, ASQC, ASNT, CSNDT, NGLI, CMVA, STLE, IIE, IMC, etc.,) - Actual hours spent in such activities
- Option 5 – Attend Conferences relevant to the subject areas in the BoK – (e.g., SMRP, ASQC, ASNT, CSNDT, NGLI, CMVA, STLE, IIE, IMC, RCM, PdM Vendor Sponsored Conferences etc.,) - Actual hours spent in conference sessions up to six hours for each day of attendance.
- Option 6 – Give presentations at conference or seminar relevant to subject areas in the BoK. Up to 40 hours to develop and deliver a paper.
- Option 7 – Publish articles or papers in publications to subject areas of the BoK – 40 hours for writing an article
- Option 8 - Author a book or a significant chapter of a book relevant to subject areas in the BoK – Actual hours spent writing the book
- Option 9 - Provide instruction for a course or workshop relevant to subject areas in the BoK – 3 hours for development and delivery for each classroom hour ( i.e., 6 hour course = 18 hours)
- Option 10 – Participate in development of questions for the CMRP Exam - 8 hours per question submitted or worked on.
- Option 11 – Other activity or learning experience in subject areas of the BoK - Submit hours for approval (by SMRPCO Certification Committee).

**d) Certificant Preparation for Audit of Recertification Claims**

Although the SMRPCO’s recertification program is conducted on an honor system of reporting, measures need to be in place to verify the accuracy of reporting. The audit process requires ten

(10) percent of applicants to furnish additional documentation that supports compliance with recertification requirements. Examples are given in paragraphs **IV.A.e)** through **o)** below of the type of documentation that is acceptable. It behooves candidates to collect and retain such documentation as the requirements for recertification are met so as to enable prompt response when requested. Failure to respond in timely fashion (to be specified in the request for verification) may be grounds for denying recertification. This obligation rests with the certificants who seek recertification.

A computerized log, a logbook, or an appointment book can provide documentation by certificants who are self-employed. Certificants who are contracted by an employer may submit a letter from an employer, conference, chapter, committee or board chairman, workshop or course sponsor on official letterhead verifying the number of hours engaged. The documentation must include the date and length of participation. Conference brochures listing papers given or copies of actual pages containing articles from publications will be accepted. Pay stubs or tax forms are **not** acceptable documentation for work experience hours for recertification.

The SMRPCO recognizes that many certificants are involved in the teaching aspect of the profession. Therefore, Certificants may claim hours for hands-on teaching. Hands-on teaching is defined as imparting of knowledge from teacher of a formal course or workshop facilitator to students or workshop participants of some aspect related to the M & R BoK

The SMRPCO recognizes that many certificants also provide hands-on work as volunteers of one or more professional societies. Therefore, certificants may claim hours for hands-on volunteer service in support of the M & R Profession.

**e) Continuing Education (Option 1)**

Continuing professional education hours must meet the following definition:

- Learning experiences in a formal school setting that are designed to facilitate continued or improved competency, including ethical and legal practice in the M & R Profession through participation in a learning process that enhances the Certificant's knowledge, skills and abilities in the profession. Audited courses are not awarded recertification credit hours. A certificate of completion or other document attesting to the Certificant's presence at

such school should be held for verification in the event of audit. The courses must be completed by dates that are within the current certification cycle and prior to submission of the application for recertification to SMRPCO

**f) Complete educational workshops or seminars relevant to subject areas in the BoK (Option 2)**

In order to meet the requirements for attaining recertification credit hours through this option, the following criteria and conditions must be met:

- Workshops and seminars must have been formally organized and scheduled in advance by a competent provider of such services and completed within the current three (3) year cycle of the certificants and prior to submission of the application for recertification to SMRPCO.
- Recertification credits hours may be claimed based on hours actually spent in the seminar or workshop.
- A certificate of completion or other documentation attesting to the Certificant's presence at such event should be held for verification in the event of audit.

**g) Participate as an active member of a SMRP or SMRPCO Board or Committee (Option 3)**

In order to meet the requirements for attaining recertification credit hours through this option, the following criteria and conditions must be met:

- Must be satisfactorily completed within the current three (3) year certification cycle and prior to submission of the recertification application to the SMRPCO.
- Name must appear in the minutes of any activity of SMRP or SMRPCO in which the Certificant participates.
- Copies of such minutes should be retained by the certificants for presentation in the event of audit.
  - (i) Must have served at least one year in the position
- Actual hours spent working on activities may be claimed for re-certification credit

**h) Attend annual/executive/chapter meetings relevant to subject areas of the M & R BoK (Option 4)**

In order to meet the requirements for attaining recertification credits through this option, the following criteria and conditions must be met:

- Must be satisfactorily completed within the current three (3) year certification cycle and prior to submission of the recertification application to SMRPCO.
- Name must appear in the minutes or attendance list of any activity in which the Certificant participates.
- Copies of such minutes or attendance list should be retained by the certificants for presentation in the event of audit.

**i) Attend conferences relevant to the subject areas of the BoK (Option 5)**

In order to meet the requirements for attaining recertification credits through this option, the following criteria and conditions must be met:

- Attendance must be completed within the current three (3) year recertification cycle and prior to submission of the recertification application to SMRPCO.
- Name must appear in the attendance list of any activity in which the Certificant participates.
- Copies of receipt for fees paid for conference and/or attendance list marked to show the Certificant's name should be retained by the certificants for presentation in the event of audit
- Six (6) hours credit may be claimed for each day of attendance.

**j) Give presentation at a conference or seminar relevant to subject areas of the BoK (Option 6)**

In order to meet the requirements for attaining recertification credits through this option, the following criteria and conditions must be met:

- Presentations may be at a conference, workshop or seminar of any organization that supports the M & R Profession.
- Must be pertinent, current and applicable to the scope of practice of the M & R Profession.
- The presentation must be at least 40 minutes in length.
- Presentation cannot be part of a panel.
- Copy of event program, workshop or seminar marked to show the Certificant's contribution to it should be retained by the Certificant for presentation in the event of audit. It must also show that the presentation was made during the current three (3) year certification cycle and before submission of the application for re-verification.

**k) Publish articles or papers in publications relevant to the subject area of the BoK (Option 7)**

In order to meet the requirements for attaining recertification credit hours through this option, the following criteria and conditions must be met.

- The article or paper must appear in a recognized periodical publication aimed at members of the M & R Profession
- The article or paper must have been published or accepted for publication within the current three (3) year certification cycle and prior to submission of the application for recertification to SMRPCO.
- A copy of the article or paper with the title page or table of contents should be retained by the certificants for presentation in the event of audit. In the event publication has not yet occurred, a letter of acceptance from the publication may be submitted that indicates the date the article will be published.
- Not to exceed forty (40) hours for writing the article.

**l) Author a book or significant chapter of a book relevant to the subject areas of the BoK (Option 8)**

In order to meet the requirements for attaining recertification credits through this option, the following criteria and conditions must be met:

- The book or significant chapter must relate directly to the practice of the M & R Profession
- Must meet one or more of the following criteria:
  - (i) Contributes to the understanding of the value of use of some M & R technique, methodology or skill.
  - (ii) Relates to the practice in the M & R Profession:
    - (a) Contributes to understanding of the profession and practice of Maintenance and Reliability
    - (b) Research or case studies on M & R practices
    - (c) Statistical research – such as trends and growth of the M & R Profession.
- The Certificant must be a principal author or contributor of a chapter of a book.
- The book must have been published or accepted for publication during the certificants current three (3) year certification period and prior to the submission of the application for recertification.

- Actual hours spent writing may be claimed, in conjunction with hours in any other option for re-certification.
- A copy of the book cover, title page and/or page upon which the ISBN data book title and author and contributors names appear may be submitted to SMRPCO for verification in the event of audit. For a book accepted for publication but not yet in print, copy of a letter of acceptance from the publisher may be submitted that includes the date the book was/will be published.

**m) Provide instruction for a course/workshop relevant to the subject areas of the BoK (Option 9)**

In order to meet the requirements for attaining re-certification credit hours through this option, the following criteria and conditions must be met:

- A course or workshop that qualifies for recertification credit must relate to the practice of M & R Profession and have been conducted within the re-certification cycle of the Certificant.
- The Certificant must be the primary instructor, co-instructor, workshop facilitator or co-facilitator.
- Course or workshop must have been formally scheduled, conducted and documented on behalf of participants within the current three (3) year certification cycle and before submission of the application for recertification.
- Certificants may claim 3 hours for development and delivery of each classroom or workshop hour (e.g., 6 hours in class or workshop = 18 hours).
- Certificants should retain and may submit any formal documentation concerning having scheduled, conducted or completed the course or workshop, in the event of audit.

**n) Participate in the development of questions for the CMRP exam (Option 10)**

The following requirements must be met in order for the Certificant to be awarded recertification credit hours under this option:

- The CMRP Question Data bank must contain the name of the Certificant as an originator and date entered into the bank of any questions submitted that have been accepted as candidate questions and claimed for recertification credit. The dates must fall within the Certificant's current three (3) year certification cycle and prior to submission of the application for recertification.

- The Exam Director, who maintains the Exam Data bank, must verify that the Certificant has been given credit for questions accepted as candidate questions.
- Certificants will be given eight (8) hours credit for each candidate question in the bank accepted within the Certificant's re-certification cycle.

**o) Other activity or learning experience related to subject areas in the BoK (Option 11)**

The following requirements must be met in order for the Certificant to be awarded recertification credit hours under this option:

- The activity or learning experience that qualifies for recertification credit hours must relate to the practice of M & R Profession and have been conducted within the current certification cycle of the Certificant and prior to the submission of the application for recertification.
- The certificants **must** submit supporting documentation with the completed for Application for Recertification Form consideration of the hours claimed.
- The SMRPCO Staff must gain the approval of the Certification Committee Chairperson to give credit for the hours claimed in each case under this option.

**p) Application Process**

Within the period from six (6) months to one (1) year before the end of their current certification cycle, applicants may submit a completed Application for Recertification form along with a non-refundable fee. The SMRPCO staff will review each application for re-certification to determine whether the applicant has met the re-certification requirements. SMRPCO staff will contact the applicant if further information is needed and a deadline will be given for submitting the additional materials. If the application is incomplete, the applicant will receive a letter specifically detailing the items that are missing. He/she will have up to 90 days from the date of the expiration of their certification to submit the missing items. If the applicant does not submit the missing items within this period, the SMRPCO will send a second letter informing the applicant that the applicant's certification status has expired. The applicant's certification status will also be terminated. If the Certificant requests to cancel the application within the period after submittal up to 90 days of certification expiration, the application and documentation will be returned and the Certificant will forfeit all fees.

**q) Auditing Process**

As stated in paragraph **IV.A.d**, above, SMRPCO's re-certification program is conducted on an honor system of reporting, however best certification practices specified by the American National Standards Institute, require measures in place to verify the accuracy of reporting. Therefore, each year the SMRPCO randomly selects certificants who apply for re-certification to be audited. The audit process currently requires ten (10) percent of applicants to further verify the claims that have been submitted to the recertification committee. Verification may be requested as far back as the beginning of the latest certification cycle during which the Certificant has applied for re-certification. Certificants will be requested to submit additional documentation within 60 days. Failure to provide documentation will result in recertification being denied. Once the additional documentation is received, it will be reviewed by the Certification Administration Manager and if acceptable, placed in the Certificant's file at SMRPCO Headquarters. If the documentation does not fulfill the requirements as specified in paragraphs **IV.A.e**) through **o**) above or is not received within the time frame specified, the applicant will be notified of the problem and provided with a second opportunity and a 30 day deadline to comply. A separate "Recertification Audit File" shall be kept by the Certification Administrative Manager indicating which applicants' requests were subjected to audit, significant dates (of request for documentation, its receipt and the results).

**r) Actions Taken Regarding Re-certification Applications**

Once an application has been reviewed, the following actions can be taken:

- **Approved** - When the application has been reviewed and it is determined that all requirements for recertification have been met, the application will be approved. Upon approval, a certificate for another three (3) year period will be issued to the applicant within 30 days.
- **Deferred** - If a recertification application is deferred (e.g., because it was chosen for audit), the specific reason(s) for that action will be made available to the Certificant in writing. Certificants who have their recertification deferred will be given the opportunity to submit additional requested materials.
- **Denied** - If a Certificant has not met the requirements for recertification, the application will be denied. In addition, should it be determined that the applicant has provided false or misleading information when applying for recertification, the Chairperson of the Certification

Committee may deny recertification and begin disciplinary proceedings in accordance with the SMRPCO's established Rules and Procedures Regarding Ethical and Professional Complaints..

**s) Appeals Process**

A Certificant who disagrees with a ruling regarding their specific re-certification status may ask for review by the Certification Committee members who did not review the initial application. This must be accomplished within 30 days of the initial ruling and the request must be made in writing (including e-mail) to the Certification Committee Chair along with reasons for requesting the appeal stating the reasons for the disagreement.

If the Certificant does not agree with the subsequent ruling, the applicant may appeal that decision in writing to the Executive Committee of SMRPCO within 30 days. The Executive Committee of SMRPCO has the final authority in ruling on all appeals.

Communications sent to the applicants during the appeals process will include instructions for or have attached a means to substantiate proof of response to an appeal request.

**t) Extension Requests**

An extension of the recertification deadline, for extenuating circumstances, may be granted for up to six months beyond the expiration date. The Certificant must submit the following information in writing before the expiration date: a statement of the extenuating circumstances, the number of completed recertification credits, the number of work hours completed and a detailed plan stating how all requirements will be fulfilled by the requested extended deadline. The Certification Committee Chair reserves the right to modify the extension. If an extension is granted, the original expiration date will remain constant. During this extension period, the individual is not certified, cannot claim to be, nor use the CMRP or other credential issued by SMRPCO. Should re-certification ultimately be granted, the original expiration date shall be the date of the beginning of the new certification cycle.

**B. Inactive Status**

Inactive status can be granted to candidates on a case-by-case basis for special circumstances. A Certificant's request for inactive status will be reviewed and granted at the discretion of the Certification Committee. Examples of conditions that might necessitate inactive status include: pregnancy, illness, injury, military duties or personal hardship. An inactive status may be granted to a Certificant for up to a maximum of three years. During this time, the individual is not certified,

cannot claim to be, nor use the CMRP or other credential issued by SMRPCO. However, any recertification credit hours taken during this period will count toward recertification. Once an applicant applies to reactivate their status, the Certification Committee will determine the length of time that the applicant has to meet the recertification requirements. If the inactive status goes beyond three years after the expiration date of the original certification or subsequent recertification, the individual's record will be annotated as certification having expired. If within this three year time frame, the individual desires to recertify, pay current recertification fee, and meet all current recertification requirements with appropriate documentation. Furthermore, the original expiration date will remain valid. If nothing has occurred within those three years, the individual's record will be identified in the SMRPCO's files as not certified.

### **C. Lapsed Status**

Certification will enter "lapsed" status for up to three months (90 days) after the expiration date of the original certification or subsequent recertification period. If within this time frame the lapsed Certificant wishes to recertify, he/she must pay the current recertification fee and meet all current recertification requirements with appropriate documentation. The Certificant's original date of expiration will remain valid as the starting point for the new certification period when the new certificate is issued. If the individual who's certification has lapsed takes no action within the 90 day time frame, that person's record will be annotated in the SMRPCO's files as not being certified and, if recognition is authorized, the listing will be removed from the SMRP website. If at a future time the formerly certified applicant wishes to become certified, they must register as a candidate, meet all eligibility requirements, and successfully complete a current form of the certification examination.

**Persons Responsible (by Title) for maintenance and explaining the contents of this document: Examination Director and Certification Administrative Administrator (Jointly)**

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## APPENDIX A

### Sample Examination Questions

1. Which one of the following is generally true?
  - A) Construction contractors are usually equally skilled at performing all maintenance tasks
  - B) Maintenance is often reduced through project designs that provide in-place spares for all rotating equipment and heat exchangers
  - C) Reliability Centered Maintenance can be applied on capital projects in the pre-construction stage to determine the maintenance plan
  - D) Most mechanics can easily alternate between doing capital project work and doing equipment diagnosis and repair work
  
2. What is the best criterion for changing a known and controlled variable to meet a new customer requirement?
  - A) Engineering analysis
  - B) Operator and maintainer experience
  - C) Senior management directive
  - D) Reliability and maintainability analysis
  
3. From the choices below, select the formula for Reliability, R:
  - A)  $R = e^{- (MTTR/t)}$
  - B)  $R = e^{- (t/MTBF)}$
  - C)  $R = \text{Downtime}/(\text{Downtime} + \text{Uptime})$
  - D)  $R = \text{MTBF} / (\text{MTBF} + \text{MTTR})$
  
4. A reliability leader has noted that the air supply to the pneumatic drill and stamping center is intermittently inadequate, resulting in costly process interruptions. Three potential solutions have been identified: 1) Purchase a new, larger air compressor for \$40,000 2) Perform and overhaul of the existing compressor for \$10,000 3) Contract a performance investigation of the air system for \$3,500. Which is the best alternative and why?
  - A) Overhaul the existing compressor to see if that solves the problem
  - B) Buy a new compressor because Mean Time Between Failure is guaranteed by the supplier
  - C) Buy a new air compressor because the existing compressor seems too small
  - D) Investigate system performance to determine the root cause of the problem

5. If a machine is run for 500 hours and five failures are observed during this period, what is the Mean Time Between Failure?
- A) 500 hours
  - B) 0.01 hours
  - C) 2500 hours
  - D) 100 hours
6. Which of the following most effectively makes up the members of a Manufacturing Team?
- A) Sales/Customer/Production/Supplier/Senior Management
  - B) Maintenance/Engineering/Production/Human Resources
  - C) Production/Maintenance/Supplier/Engineering
  - D) Senior Management/Production/Human Resources
7. What is the most important purpose of performing risk evaluations?
- A) To determine what level of response is cost justified
  - B) To clearly define activities required to contain risks
  - C) To identify what events may have serious consequences
  - D) To assure compliance with company policies
8. Of the following, what is the best method for measuring employee skills and training?
- A) Create and maintain a skills inventory tracking database
  - B) Ask employees to keep a training notebook
  - C) Keep records of all formal training courses taken
  - D) Have employees complete annual self-evaluations
9. When training maintenance workers, it is best to first:
- A) List all the tasks the workers need to perform
  - B) Check the budget to set how much to spend per worker
  - C) Review the list of classes already taken by the workers
  - D) Give classes to all workers on basic skills
10. What relationship should Maintenance and Reliability Teams have with customers and suppliers for optimum effectiveness?
- A) Purchasing should be the only communicators with suppliers
  - B) Supervision should be the only communicators with customers and suppliers
  - C) Team members should be involved in communicating with customers and suppliers
  - D) Sales should be the only department communicating with customers

11. Which of the following metrics definitions is not accurate?
- A) Uptime - % of time you run producing quality product at design rate
  - B) Schedule compliance - how often mechanics are pulled off their current work to another task
  - C) MTBF - a measure or indicator of equipment life expectancy
  - D) Backlog - how long it takes to fix broken equipment
12. Which of the following does not support people development?
- A) Providing feedback only when asked
  - B) Defining result areas, goals, and measurements
  - C) Coaching, feedback, and encouragement
  - D) Defining training and skills goals
13. From the following list, which is not a critical structural element of a strategic plan for maintenance and reliability?
- A) Current levels of performance
  - B) Benefits available through implementation
  - C) Historical direction of the business
  - D) Vision of the future state
14. Which performance result best shows a maintenance and reliability manager that the scheduled maintenance activities being implemented are effective?
- A) Hours spent on unscheduled maintenance have decreased
  - B) Maintenance cost per unit of production has decreased
  - C) Total annual maintenance cost has decreased
  - D) Production rate has increased
15. When the time period between the testing which detects a failure and the failure actually occurs is highly variable, and the life expectancy is highly variable, a good approach is:
- A) More frequent periodic predictive testing
  - B) Structured preventive maintenance
  - C) On-line condition monitoring
  - D) Time based rebuild or changeout

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Answer Key to Sample Questions

1. C
2. A
3. B
4. D
5. D
6. C
7. A
8. A
9. A
10. C
11. D
12. A
13. C
14. A
15. C