



**SOCIETY OF ALLIED
WEIGHT ENGINEERS, INC.**

*Aerospace • Marine • Offshore •
Land Vehicle • Allied Industries*

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2020 SAWE MPE CERTIFICATION OUTLINE OF REQUIREMENTS

Prepared by
MPE Certification "Technical Team"
for
Society of Allied Weight Engineers, Inc.
(SAWE, www.sawe.org)



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1 Introduction

1.1 Overview

This document provides a draft outline of the proficiency requirements for achieving each level of SAWE Mass Properties Engineering (MPE) Certification. This outline is designed as an aid in developing the appropriate training classes and exams to ensure that the candidate is qualified to receive the honors, rights and privileges associated with each level of MPE credentials. Questions regarding this document should be addressed to Andy4Schuster@gmail.com.

1.2 Purpose

These requirement will be used by the authors and the Industry Committee that they represent, to define the currently available and required reference documents and training materials. The difference between the available and required materials is a “gap” that will need to be filled with new materials.

1.3 Current Overall Process

This committee completes steps 1 and 6. Steps 2-5 are done by each Industry Committee.

1. Define requirements for a level of MPE certification, starting with the lowest (AMPE)
2. Determine all the references for the candidate to review and understand before being certified
3. Determine how that reference material should or could be delivered to the candidate. (e.g. by online class, face to face class, back ground reading, workbook, etc)
4. Determine whether the current training materials adequately address the requirements
5. Create a list of reference and training materials that need to be developed.
6. Add findings to a summary report
7. Return to step 1 for the next level MPE certification
8. Present summary report to the project management team.

1.4 Terms & Abbreviations

| Item | Description |
|-----------------|---|
| AA | Airline Affairs Industry Committee |
| Airline Affairs | is also known as “Commercial Aircraft” or “Non-Military Aircraft” |
| AMPE | Associate Mass Properties Engineer see section 2 for a definition |
| ANSI | American National Standards Institute |
| ANSI-CAP | American National Standards Institute – Certification Accreditation Program |
| BE | Bachelor of Engineering |
| BS | Bachelor of Science |
| CoG, CG | Center of Gravity |
| Cross Industry | SAWE RPs that cover fundamental MPE principals, practices or |

| Item | Description |
|-----------------|--|
| | methods that are applicable to all industries |
| CX | Cross Industry Committee |
| EMPE | Expert Mass Properties Engineer |
| FBS | Functional Work Breakdown Structure, for grouping MPs by system or functionality (landing, weapons, fuel etc) |
| Gap | The difference between available and required materials. The gap must be closed by creating new materials for the program to move forward. |
| Ground Vehicles | Trucks, cars, tractors, tanks, rovers, trains, trams, buses, mopeds, motorcycles, etc |



| Item | Description |
|---------------------------|--|
| GV | Ground Vehicle Industry Committee |
| HazId | Hazard identification study for a new or design for purpose project |
| HazOp | A set of operation instructions to assure accidents identified in the HazId are mitigated or avoided or addressed. |
| Hr or hr | Hour |
| IMP | Interface Management Plan |
| Industry Committee | Are the SAWE Standards and Practices committees that meet at the International Conference including Marine, Military Aircraft, Ground Vehicle, Offshore, Missile & Space System, Airline Affairs and Cross Industry. |
| M | Marine Industry Committee |
| MAC | Military Aircraft Industry Committee |
| Marine | Government owned or purchased or chartered combatant and cargo ships. |
| Military Aircraft | Government owned or purchased fixed wing, rotary, drones, cargo aircraft. May include bombs too? |
| Missile and Space systems | Launch vehicles, rockets, satellites, space stations, lunar or mars ground based systems (rovers, habitats etc) |
| MP | Mass Properties – the discipline or the attributes (weight, cog, inertia, volume etc) |
| MPCP | Mass Properties Control Plan |
| MPE (depends on context) | Mass Properties Engineer – person engaged in Mass Properties Engineering activities Mass Properties Engineering – all actions and skills needed to assure the final product is within mass properties limits Or depending on context Mass Properties Engineer |

| Item | Description |
|--------------------|--|
| MSS | Missile & Space Systems Industry Committee |
| OBS | Organizational Work Breakdown Structure, for grouping MPs. (by subcontractor, department, discipline etc.) |
| Offshore | Boats, floating production units, mobile drilling units, gravity base structures, submersibles etc use to produce oil, gas, wind power, fisheries etc that operate in lakes, rivers, seas and oceans |
| PMPE | Professional Mass Properties Engineer |
| References | For this project includes: SAWE technical papers, RPs, textbooks, guidelines, and handbook. |
| RP | SAWE Recommended Practices The MPE RPs for specific industries included: A7 for Military Aircraft G1 for Ground Vehicles M1 for Marine Vehicles A-3 for Missiles and Spacecraft |
| SEMP | Systems Engineering Management Plan |
| STEM | Science Technology Engineering and Mathematic (degree or programs) |
| Ton | Unit of mass typically 2000 pounds, unless specified differently |
| Training Materials | For this project includes: slides, syllabus, instructor notes, exercises, class test, hardware (e.g. for weighing an aircraft) |
| WBS | Work Breakdown Structure, for grouping MPs. This can be a generic or specific term. OBS and FBS are types of generic WBSs. |
| WCP | Weight Control Plan, similar to MPCP, for the marine and offshore industries, as used in this document |



2 Certification Levels Summary

The following table provides an initial plan for three levels of MPE certification.

The levels are ONLY intended as a Work Breakdown System to identify all the requirements so that the “gaps” in references and training materials, can be identified. The final levels, divisions of knowledge, experience etc as well as the titles will be defined by the management team and approved by the SAWE BoD.

The levels as shown below the Associate MPE (AMPE) level is a cross industry certification designed to ensure the candidate has a basic set of knowledge and skills to effectively support their projects in the area of mass properties control across all industries. The next two higher levels of certification, PMPE (Professional MPE) and EMPE (Expert MPE), ensure industry specific proficiency.

| Airline Affairs | Ground Vehicles | Marine | Military Aircraft | Missile & Space | Offshore | Prerequisite |
|---|----------------------------------|---------------------------------|-----------------------------------|-----------------------------------|---------------------------------|-------------------------------|
| Expert (EMPE-AA) | Expert (EMPE-GV) | Expert (EMPE-M) | Expert (EMPE-MAC) | Expert (EMPE-MSS) | Expert (EMPE-O) | PMPE +10 yrs Total Experience |
| Professional (PMPE-AA) | Professional (PMPE-GV) | Professional (PMPE-M) | Professional (PMPE-MAC) | Professional (PMPE-MSS) | Professional (PMPE-O) | AMPE + 5 yrs Total Experience |
| Associate (AMPE) - Based on Cross Industry RPs | | | | | | 2-5 yrs Experience |

Additional Prerequisites are defined in Section 3 and 4.



3 Outline of Requirements by level of Certification

3.1 Associate Mass Properties Engineer (AMPE)

As previously mentioned, the AMPE level of certification is **not industry specific**, but rather focused on the common and shared knowledge of MPE. The proficiency requirements are defined below.

Associate MPE Level Requirements:

- Minimum Experience:
 - Bachelor's Degree in a science, technology, engineering or mathematics field of study, and 2 years of MPE experience. **OR**
 - 5 years of applicable MPE related experience.
- Current SAWE member.
- Successful completion of AMPE exam showing proficiency in the following skills:
 - Ability to calculate volume, mass, center of gravity, moments of inertia and products of inertia for an object and/or a collection of objects using material density and fundamental shape and summation equations.
 - Experience calculating mass properties using 3D CAD tools (e.g. CATIA, NX, and/or other)
 - Knowledge of mass properties measurement concepts and techniques.
 - Basic understanding of strength of materials, stress, strain and loads.
 - Basic knowledge of fluid mechanics and buoyancy principles.
 - Basic understanding of subsystem design processes (e.g. structure, propulsion, power, electronics, wiring, controls, etc.)
 - Knowledge of mass properties control methods including risk management.

3.2 Professional Mass Properties Engineer (PMPE)

As previously mentioned, the PMPE level of certification is **industry specific**, and the proficiency requirements are defined by each SAWE industry committee.

Professional MPE Level Requirements:

- AMPE level certification
- 5 years of total MPE experience.
- Current SAWE member.
- Successful completion of PMPE exam showing proficiency in the following skills:
 - To be defined by each SAWE industry committee.

3.3 Expert Mass Properties Engineer (EMPE)

As previously mentioned, the EMPE level of certification is **industry specific**, and the proficiency requirements are defined by each SAWE industry committee.

Expert MPE Level Requirements:

- PMPE level certification.
- 10 years of total MPE experience.
- Current SAWE member.
- Successful completion of EMPE exam showing proficiency in the following skills:



- To be defined by each SAWE industry committee.

3.4 General Notes for Sections 4 & 5

- Unless stated otherwise, all requirements assume the lower level plus. So an expert must meet the requirements of an associate and Professional MPE.
- Skip Levels - MPEs with the requisite experience may bypass the Associate and Professional levels if they can pass all the tests to become an Expert.
- Multiple Industry Expert MPE – EMPE may qualify for a second or third industry by taking the industry exam and meeting the required project experience.
- Technical Paper - To write and present a peer reviewed SAWE paper at a SAWE regional or annual conference on a topic suggested by the VP Technical Director or VP Standards and Practices, author a working draft of an RP, or chapters in a textbook.
- MP Fundamentals – includes are the content in the Cross Industry RPs - *Risk Management, Metrics, Economics, Baseline Control, Program Requirements, Optimization, Estimating, Calculating Weighing, Reporting, In-Service, Data Transfer*
- The requirements are broken into two sets with the following high level breakdown:
 - Cross Industry – All Applicants
 - (1) Experience
 - (2) Safety
 - (3) leadership
 - (4) MPE fundamentals
 - (5) Engineering Knowledge
 - (6) Process
 - (7) Software
 - (99) Miscellaneous (which needs to be refiled in another category)
 - Industry Specific - By Standards and Practices Industry Committee
 - Commercial Aircraft or Airline Affairs Industry Committee
 - Ground Vehicle
 - Marine
 - Military Aircraft
 - Missile and Space Systems
 - Offshore



4 Cross Industry – All Applicants - Requirements

| Item | Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|-------------|-----------------------------|--|---|---|
| 1.00 | Experience | | | |
| 1.10 | Experience - Work | <ul style="list-style-type: none"> • Entry level in industry (either) <ul style="list-style-type: none"> ○ 5 years of applicable MPE related experience. ○ 2 years of applicable MPE related and completion of a BS/BE STEM degree • Working in a MPE group • Use of CAD tools, hand calculations and other computer tools to calculate MP | <ul style="list-style-type: none"> • 5 years of total MPE experience • Leading a project during one or more phases • Checking work of associates • Can qualify for a second industry certification by taking the training and passing the industry specific exam. | <ul style="list-style-type: none"> • 10 years of total MPE experience • 3 years in at least one industry |
| 1.11 | Experience – Project | One Project | 2 projects or major phases | 4 projects or 4 phases on 2 different projects |
| 1.20 | Pre Requisite certification | none | Hold a AMPE certification for 1 year | Hold a PMPE certification for 1 year or AMPE for 3 yrs (but must take both exams) |
| 1.30 | Industry Specific | none | General or all industries Or specific to an industry | Specific to industry |
| 1.40 | SAWE Membership | Current | 3 yrs | 5 yrs continuous |
| 1.50 | Formal Training | | | |
| 1.51 | On-Line Classes | 30 hr | 30 Hr or more | 30 hr or more per industry |
| 1.52 | In person Classes | Total of 4 hr at a regional | Total of 8 hrs at regional or international conference of which 4 hrs at a regional or international conference after qualifying as a AMPE. | Total of 16 hours of which 8 hrs at a regional or international conference after qualifying as a PMPE. |
| 1.60 | Exam | | | |
| 1.61 | No of Questions | Complete (100 multiple choice) | Complete (200 multiple choice) | Complete (50 multiple choice) |
| 1.62 | Language | In American English only | In American English only | In American English only |
| 1.63 | Available | In all countries (e.g Europe, Brazil, China, India, Malaysia, Korea, Kuwait, etc) | In all countries (e.g Europe, Brazil, China, India, Malaysia, Korea, Kuwait, etc) | In all countries (e.g Europe, Brazil, China, India, Malaysia, Korea, Kuwait, etc) |
| 1.70 | Sponsor/mentor | A PMPE in the organization or SAWE assigned | A EMPE in the organization or SAWE | Another EMPE |
| 1.80 | Contribution to Profession | None | 1 technical paper | <ul style="list-style-type: none"> • 2 more technical papers • One paper should expand the knowledge base of MPE. |



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| Item | Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|-------|---|---|---|--|
| | | | | <ul style="list-style-type: none"> Mentor an AMPE |
| 2.00 | Safety | Know safety limits (weight & CoG) Examples in the Industry Specific Requirements | Set and enforce limits (project or product line) Sign off on authorizations (Form F) Example in the Industry Specific Requirements | Derive or establish limits and policies Offshore- with HazID and HazOP analysis Examples in the Industry Specific Requirements |
| 3.00 | Leadership & Interpersonal Skills Update with pats details | Work with other disciplines to determine current data Prepare and organize a meeting | One on One skill <ul style="list-style-type: none"> How to interview a Discipline Lead How to prepare chair and close out a meeting How to report status to management How to motivate, mentor, council staff How to check work without redoing it. | Lead a group <ul style="list-style-type: none"> Chair teams to control, optimize MPs Department leadership of a MPE and others Industry committee co-chair SAWE officer leadership Community committee leadership |
| 4.00 | MPE Fundamentals | | <ul style="list-style-type: none"> | <ul style="list-style-type: none"> |
| 4.1 | Design Development | Familiarity with the Cross Industry RPs to be able to complete actions, or calculations or fill in equation as defined in the project plan or company procedures or RPs | <ul style="list-style-type: none"> Write a MPC or WCP plan based on customer requirements. For estimating be able to derive parametric equations Derive a Bill of Materials from a parametric weight estimate (e.g. long lead items) Be able to check work of others | <ul style="list-style-type: none"> Define plan requirements Maintain overall quality control Approve work of others |
| 4.2.1 | Validation Andy Schuster | Weight calcs Estimates | <ul style="list-style-type: none"> checking model validation | <ul style="list-style-type: none"> approval |
| 4.2.2 | Validation Andy Walker | <ul style="list-style-type: none"> Basic concept knowledge of techniques to validate Mass Prop estimation, calculation, and measurement methods | <ul style="list-style-type: none"> Calibrate high-level methods for estimation, calculation, and measurement with historical and/or higher-fidelity data Establish/ Document calibration factors for validated models Identify reasons why current estimate diverges from validated design metrics (e.g. % Body-Length CG, Weight per Measured Area, Group Weights as % of Gross Weight, Analytical Mass Distribution) | <ul style="list-style-type: none"> Establish reasonability checks for model validation Able to ensure/ certify that estimation models have enough validation to meet quality control requirements |
| 4.3 | Verification | Able to follow procedures to weight an item. <ul style="list-style-type: none"> Basic knowledge of techniques for weighing, CG and inertia measurement | <ul style="list-style-type: none"> Write weighing procedure Define verification requirement Develop verification plan | define Weighing plan for a project <ul style="list-style-type: none"> Experience with test equipment procurement process |



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| Item | Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|------|--|---|--|--|
| | Provided by Bell Lee | <ul style="list-style-type: none"> • Understand required data collection from testing • Perform verification by analysis • Perform uncertainty analysis | <ul style="list-style-type: none"> • Develop test procedure • Knowledge of subcontract development (SOW) and coordination to define required EIDP • Develop parametric tools using verification data • Mentor junior engineers on verification methodology and processes | <ul style="list-style-type: none"> ○ Solid understanding of requirement driver to determine verification by analysis vs. testing ○ Experience in proposal work in relation to cost estimation in verification/validation |
| 4.4 | MP Measurement SAWE Paper 2444 | Steps in Making MP Measurements Establish a frame of reference Choosing a fixture Methods used to measure CG Location MOI Measurement Considerations in choosing a MP Instrument Weight Measurement Proper reporting of MP Measurement (ARS) | | <ul style="list-style-type: none"> • |
| 4.5 | Design Of Fixtures SAWE Paper 2190 | <ul style="list-style-type: none"> • Establish a frame of reference • Effect of fixture error on MP Measurement • Desirable attributes of MP fixtures • Basic types of payload fixture interface • Generic types of fixtures • Custom Fixtures – Golf clubs, bombs, cars, space craft, 21' motor boat, etc • Peripheral hardware and software • Getting best performance from fixtures Proper reporting of Fixture design choice, use.(ARS) | | |
| 4.6 | Customer and Contract Requirements (David Tellet) | Understand the basic relationships between customer and provider: <ul style="list-style-type: none"> • Specification process • Not to exceed (NTE) values • Incentives and penalties • Information flow • Regulations | Provide input to the contractual process: <ul style="list-style-type: none"> • Review specifications • Develop NTE values • Assess MP performance • Enforce data flow process | <ul style="list-style-type: none"> • Represent MPE in contract negotiations • Establish incentive policies • Develop information flow process • Develop and sign off on specifications and regulations |



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| Item | Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|-------------|---|--|--|---|
| | | <ul style="list-style-type: none"> Technical Authority | | |
| 5.00 | Engineering Knowledge | | | |
| 5.10 | MP Engineering | Fundamentals (i.e. estimate, calculate, weighing, report/control cycle) How to interpret, implement (with guidance) SAWE RPs & Standards. | <ul style="list-style-type: none"> Understand the interactions between disciplines, timing of decisions on mass properties, margin derivation etc. Knowledgeable of all applicable <ul style="list-style-type: none"> Cross Industry RPs Wt Eng Handbook SAWE MPE textbooks For each industry, be familiar with <ul style="list-style-type: none"> MPC RPs (M-1, A-7, A-3, G-1, etc) Systems level knowledge How to size the systems, estimate terminology limit calculations Safety & Operational limits calculate MOI, POI, CoG, Wts | <ul style="list-style-type: none"> Develop new concepts that address new or reoccurring issues. At least one paper required that should expand the knowledge base of MPE (expansion to be defined by VP-Tech). Expert on the industry specific RPs, (M-1, A-7, A-3, G-1, etc) and textbook |
| 5.20 | System Engineering <i>(Perhaps INCOSE can help us with materials, training and materials?)</i> | Fundamentals | Systems Engineering working knowledge <ul style="list-style-type: none"> Understand the double V Understand product and methods equal to an Associate Certified System Engineer | Meet the qualifications of a Professional Systems Engineer Professional by INCOSE <ul style="list-style-type: none"> Experience Actual certification is optional, |
| 5.30 | Sub Systems Structures, Fluids, Electrical, Mechanical, Cargo/Weapons, etc. | Introductory Level (college text or a high level) Fill in the blank calculations | <ul style="list-style-type: none"> Understand similar systems in all industries, interactions and MP relationships Derive high level weight related parametric for systems for analogies and checking of proposed concepts or changes. | In-depth knowledge about an industry or vehicle system. <ul style="list-style-type: none"> Sizing Weight drivers Various configurations history of technology |
| 6.00 | Process | Understand the design and acquisition processes (spiral, set based, US government, commercial airline, private citizen) | <ul style="list-style-type: none"> Implement processes Define budgets Define schedules How to create a MPE Plan, Weighing Plan, In-service WCP | Develop a new department, with policies, procedures mentoring etc. |



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| Item | Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|------|--|---|--|--|
| | | | <ul style="list-style-type: none"> How to integrate MPE plan with SEMP, IMP etc How to budget man-hours, and schedule activities How to lean a process or organization to make MPC more effective (know of some things that work) | |
| 7.00 | Software (Giorgio Prviati & Andy Schuster) | <p>Understand how to use Excel Spreadsheets Difference between database types</p> <p style="color: red;">Understanding of programming fundamentals:</p> <ul style="list-style-type: none"> - loops - if cycles - data types - functions - input/output variables <p>Creation of a simple spreadsheet for mass properties combination (sum of mass, CoG, inertia)</p> <p>Creation of datasheets and/or program codes for standard measurement activities (mass and CoG measurements)</p> <p>Understanding of data exchange and data formats (standards, protocols and conventions).</p> <p>Understanding of the statistical tools of Excel, able to compute basic statistical variables form data series.</p> <p>Creation of clear and readable plots and graphs. Able to create a presentation in Power Point.</p> | <p>Manage the 3CAD tool by understanding how to check catalog how to track changes update schedules part number vs MPE WBS Data exchange protocols RP M11 for CAD systems</p> <p style="color: red;">Software management</p> <ul style="list-style-type: none"> - debugging - validation - version tracking - comments/manuals <p>Creation of datasheets and/or a program code for</p> <ul style="list-style-type: none"> - uncertainty computation (Montecarlo simulation and error propagation) - mass prediction (with targets, updates and tracking during a project evolution) - modeling a complex test activity with uncertainty management - assessing statistical trends and forecasting <p style="color: red;">Management of data exchange inside the workgroup and with clients and suppliers</p> | <p>Set up a MPE database and analysis suite of software (requirements, testing, etc)</p> |
| 8.00 | Analysis (By David Tellet) | <p>Be familiar with statistical and probability tools and methods:</p> <ul style="list-style-type: none"> Basic statistical variables: skew, mean, | <p>Enforce industry specific analysis guidelines:</p> <ul style="list-style-type: none"> Data requirements (e.g., data dictionaries). Evaluate and use data analysis tools: | <p>Develop and approve data analysis tools:</p> <ul style="list-style-type: none"> Establish analysis guidelines (e.g., what is an outlier, minimum data set, |



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| Item | Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|-------|---------------------------------------|--|--|--|
| | | median, standard deviations, probability distributions. <ul style="list-style-type: none"> Error analysis, precision, accuracy, sensitivity, bias. Forecasting, extrapolation, curve fitting, confidence bounds, probability calculations. Data analysis: exploratory data analysis, Monte Carlo method, ANOVA, risk analysis. | weight margin trends, forecasting, etc. <ul style="list-style-type: none"> Develop and/or assess trend analysis, risk analysis, forecast reports. | etc.). <ul style="list-style-type: none"> Approve data analysis reports. Develop data collection and analysis process and requirements. |
| 9.00 | Mass Modeling (by Bell Lee) | <ul style="list-style-type: none"> Basic concept knowledge of part/drawing indenture and work breakdown structure Familiar with basic mass properties calculations General understanding of mass properties tools General understanding of CAD General understanding of mass growth allowance (MGA) or equivalent uncertainty factors <p style="background-color: yellow;">Basic Equations by DAMIAN???</p> Examples: Sum of mass, CoG, inertia equations, what do they mean | <ul style="list-style-type: none"> General understanding of product design (in your field) Solid understanding of parametric estimation in relation to modeling Solid understanding of how to apply MGA or equivalent uncertainty factors Formulate modeling approach in relation to customer (internal and external) interface Develop mass properties analysis tools (miscellaneous analyses) Mentor junior engineers on modeling approach | <ul style="list-style-type: none"> Solid understanding of product design and concept development (in your field) Experience with mass properties tool development and procurement process First order estimation technique in relation to modeling for proposal and early program works Subject matter expert in model reviews |
| 10.00 | Reporting | <ul style="list-style-type: none"> How to use a client's WBS, how to build a WBS Basic elements of a MP Report, and the audience One Page executive summary Content of a report (hierarchical by OBS, WBS, FBS), trends, changes etc Describe How To: <ul style="list-style-type: none"> present to management <ul style="list-style-type: none"> report an MP impact or a change order Uncertainty of mass, cog, inertia, buoyancy etc. Extrapolate part weights when the exact size is not available. | <ul style="list-style-type: none"> How to check a MPE How to identify trends Manage baselines and changes determine loads manage cycle times How to track WIP | Develop budgets and schedule for Rpts Determine design maturity curves Develop Risk curves Develop management dialog about weight control issues shown in report |



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| Item | Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|------|-------|---|---|---|
| | | Basic understanding of configuration management, weight goal allocation Weight Control Process - Working knowledge <ul style="list-style-type: none">• Cradle to grave• Able to explain to others | | |

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5 Industry Specific - Requirements

| Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|--|--|--|--|
| Commercial Aircraft | | | |
| Ground Vehicles From Andy Schuster | | Knowledge of Hydrostatic Calculations 1. Ability to calculate hydrostatic properties 2. Understanding of the relationships between the hydrostatic properties 3. Ability to analyze Displacement and Other Curves Drawing 4. Knowledge of proper treatment of tanks, appendages, and freefloods etc. in hydrostatic calculations 5. Knowledge of ocean environments. | PMPE plus: <ul style="list-style-type: none"> Making policy decisions and recommendations for ship class specific terms and definitions. |
| Marine 1 From David Tellet | | Knowledge of Naval Architecture Terms and Definitions: 1. Ship coordinates, frame and deck numbering, major ship components 2. Ship types, uses 3. Hydrostatic terms and coefficients 4. Conditions A, A-I, N, N sub etc. | PMPE plus: <ul style="list-style-type: none"> Reviewing and approving hydrostatic property calculations. Establishing policy or standard methods for hydrostatic calculations. |
| Marine 2 From David Tellet | | Knowledge of Hydrostatic Calculations 1. Ability to calculate hydrostatic properties 2. Understanding of the relationships between the hydrostatic properties 3. Ability to analyze Displacement and Other Curves Drawing 4. Knowledge of proper treatment of tanks, appendages, and free floods etc. in hydrostatic calculations 5. Knowledge of ocean environments. | PMPE plus: <ul style="list-style-type: none"> Establishing policy or standard methods for weight control. Review and approve weight control plans. Development of recommended practices. Establishment of required margins. Approval of weight reports. Development of mass properties sections of contracts. |
| Marine 3 From David Tellet | | Knowledge of Weight Control Processes 1. Knowledge of weight estimating methods 2. Ability to develop and analyze weight control plans 3. Knowledge of recommended practices 4. Knowledge of weight reporting process 5. Knowledge of margin calculations | PMPE plus: <ul style="list-style-type: none"> Establishment of stability criteria. Approval of stability calculations. Establishing policy or standard methods for stability calculations. |



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| Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|--------------------------------------|--|--|--|
| | | 6. Knowledge of Weight Report Content and Format 7. Ability to evaluate weight report including ability to analyze weight and margin trends. 8. Knowledge of Contractual Requirements for margins, incentives, liquidated damages, and deliverables. | <ul style="list-style-type: none"> Establishing policy or standard methods for inclining experiments and trim dives. |
| Marine 4 From David Tellet | | Knowledge of Stability Requirements and Processes 1. Knowledge of GM/BG and righting arm criteria 2. Ability to perform a stability analysis including: <ol style="list-style-type: none"> Ability to calculate and analyze righting arm curves Knowledge of free surface calculations (large and small) Ability to apply Surface Ship and Submarine stability criteria 3. Ability to collect and evaluate stability data <ol style="list-style-type: none"> Knowledge of spreadsheet and database tools Knowledge of basic statistical functions Ability to develop and analyze class-wide stability trends 4. Ability to perform an inclining experiment or trim dive. | PMPE plus: <ul style="list-style-type: none"> Establishment of reporting processes and requirements. Approval of mass properties reports. Reporting of mass properties to senior management. Negotiating with other parties with regard to mass properties requirements, limits, margins, etc. |
| Marine 5 From David Tellet | | A. Knowledge of In-Service Reporting Requirements and Processes 1. Knowledge of Customer or Government reporting requirements. <ol style="list-style-type: none"> Reporting sequence and schedule Responsibilities of all parties Content and format of reports 2. Ability to work with shipyards, government entities, customers, certification bodies. <ol style="list-style-type: none"> Resolving errors Providing guidance Presentation of evaluations and recommendations | PMPE plus: <ul style="list-style-type: none"> Development of design guidance documents. Approval of ship specifications. |
| Marine 6 | | Knowledge of Design Guidance Documents including design notebooks, ship specifications, etc. | |



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| Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|--|---|---|--|
| From David Tellet | | | |
| Marine 7 Andy Schuster | <ol style="list-style-type: none"> 1. Hydrostatic based draft calculations 2. HVAC, weapon systems, hotel, cargo 3. Materials 4. Weight Reduction calculations, <ul style="list-style-type: none"> • | <ol style="list-style-type: none"> 1. Describe a Vendor weight control plan 2. Be able to identify and use 10 of the 14 weight estimating methods defined in the RPs (14 and C-09)- 3. Add Requirement 6 Validation (weighing) 4. Describe weighing of a small vs large object (40 oz vs 40,000 tons) | Derive a Bill of Materials from a concept level weight estimate. |
| Military Aircraft | | | |
| Missiles & Space Pat Borden General Skills - Discretion / Latitude | <ul style="list-style-type: none"> • Applies discretion and judgment to complete assignments of moderate scope and complexity. • Works under very general supervision, usually by a Lead Mass Properties Engineer, and must be able to follow specific, detailed instructions. • Work is reviewed for soundness of technical judgment and overall adequacy. | <ul style="list-style-type: none"> • Independently determines and develops approach to solutions, performing work without appreciable direction. • Exercises considerable latitude in determining technical objectives and approaches to assignment. • Work is reviewed upon completion for adequacy in meeting objectives and from a relatively long-term perspective for desired results. | <ul style="list-style-type: none"> • Works under consultative direction towards predetermined long-range goals and objectives, acting independently to uncover and resolve issues associated with the development and implementation of operational programs. • Assignments are often self-initiated, determining and pursuing courses of action necessary to obtain desired results. Plans research & development programs and recommends technological application programs to accomplish long-range objectives. • Work is checked only to the effectiveness of results obtained, typically requiring a long-term perspective. • Virtually self-supervisory. |
| Missiles & Space Pat Borden General Skills - Impact | <ul style="list-style-type: none"> • Contributes to the completion of milestones associated with specific projects. • Failure to achieve results or erroneous decisions or recommendations may cause delays in program schedules and may result in the allocation of additional resources. | <ul style="list-style-type: none"> • Guides the successful completion of major programs/projects and may function in a project leadership role. • Erroneous decisions or recommendations would typically result in serious program delays and considerable expenditure of resources along with failure to achieve major organizational objectives. | <ul style="list-style-type: none"> • Designs research and develops highly advanced new applications resulting in new products/business opportunities. • Erroneous decisions or recommendations would typically result in failure to achieve critical organizational objectives and affect the image of the organization's technological capability, along with having a long-term negative effect on organization's reputation and business, and financial posture. |



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| Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|--|---|---|---|
| Missiles & Space Pat Borden Knowledge | <ul style="list-style-type: none"> ▪ Frequently uses and applies technical standards, principles, theories, concepts, and techniques to complete assignments of moderate scope and complexity. | <ul style="list-style-type: none"> ▪ Complete understanding and wide application of technical principles, theories and concepts, in the field. ▪ Applies extensive technical expertise, and has full knowledge of other related disciplines. | <ul style="list-style-type: none"> ▪ Exhibits an exceptional degree of ingenuity, creativity, and resourcefulness. ▪ Applies and/or develops highly advanced technical technologies, scientific principles, techniques, theories and concepts. ▪ Viewed as an expert within the field. |
| Missiles & Space Pat Borden General Skills - Liaison | <ul style="list-style-type: none"> ▪ Contacts are primarily internal company contacts with infrequent inter-organizational and outside customer contacts on routine matters. | <ul style="list-style-type: none"> ▪ Contacts are frequently inter-organizational and with outside customers. ▪ Represents the organization as the prime technical contact on contracts and projects, providing solutions to difficult technical issues associated with specific projects. ▪ Interacts with senior external personnel on significant technical matters often requiring coordination between organizations. | <ul style="list-style-type: none"> ▪ Serves as organization spokesperson on advanced projects and/or programs and advises management and customers on advanced technical research studies and applications. ▪ Consultant to top management in long-range planning concerning new or projected areas of technical research and advancements. ▪ Prime external spokesperson for the company on highly significant matters relating to research, engineering matters, programs, and technical capabilities. ▪ Often instrumental in attracting and obtaining major new business. |
| Missiles & Space Pat Borden General Skills - Problem Solving | <ul style="list-style-type: none"> ▪ Provides and/or develops solutions to a variety of technical problems of moderate scope and complexity. | <ul style="list-style-type: none"> ▪ Develops and/or provides technical solutions to complex problems which require the regular use of ingenuity and creativity. Solutions are imaginative, thorough, and practicable, and consistent with organization objectives. | <ul style="list-style-type: none"> ▪ Provides solutions which are highly innovative and ingenious on unusually complex technical problems. ▪ Develops information which extends knowledge in a given field. ▪ Information may form the basis of newly developed concepts, theories, and products. |
| Missiles & Space Pat Borden General Skills | <ul style="list-style-type: none"> ▪ Bachelors degree from an accredited college in an engineering/technical discipline, with 2 years of professional experience; or no experience required with a related Masters degree. ▪ Considered experienced and emerging career level, but still a learner. | <ul style="list-style-type: none"> ▪ Bachelors degree from an accredited college in an engineering/technical discipline, with 9 years of professional experience; or 7 years of professional experience with a related Masters degree. ▪ Considered an emerging authority. | <ul style="list-style-type: none"> ▪ Bachelors degree in an engineering/technical discipline from an accredited college in a related discipline, with 20 years or more of professional experience; or 18 years with a related Masters, or 15 years with a related PhD degree. |



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| Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|---|--|---|---|
| –Typical Minimums | | | <ul style="list-style-type: none"> ▪ Considered an expert, authority in discipline, and viewed as the most senior authority in discipline. |
| Missiles & Space Pat Borden Technical Skills – General Skills | <ul style="list-style-type: none"> ▪ Interprets detailed designs from manufacturing drawings or standard modeling software tools. ▪ Knowledge and some proficiency with Microsoft Word, Excel and Power Point, solid modeling applications, and other software tools. ▪ Familiar with and perform basic mechanical analysis including statics, kinematics, error analysis, tolerance stack up, etc. | <ul style="list-style-type: none"> ▪ Expert with standard tools and techniques including improvements and development. ▪ Competent with Microsoft Word, Excel and Power Point, solid modeling applications, with an understanding of other software analysis tools. ▪ Performs complex mechanical analysis including statics, kinematics, error analysis, tolerance stack up, etc. | <ul style="list-style-type: none"> ▪ Oversight activities of engineers working with standard tools and techniques. ▪ Competent with all communication applications as well as complete understanding of all analysis tools. ▪ Competent in complex mechanical analysis including statics, kinematics, error analysis, tolerance stack up, etc. |
| Missiles & Space Pat Borden Technical Skills – Mass Properties Engineering Skills | <ul style="list-style-type: none"> ▪ Calculates mass properties (mass, 3 axis centers of gravity, and moments of inertia) of components and performs summation calculations into assemblies. ▪ Understanding of mass properties concepts, able to perform calculations by hand, and develop simple software calculation tools. ▪ Understanding of standard mass properties analysis concepts like transformations, rotations, mass distributions, and uncertainties; applies skills to preliminary design estimation. ▪ Familiar with mass properties calculation tools. ▪ Understand requirements flow-down and subsystem mass properties allocations. ▪ Understand development of program SOW and cost quotes. ▪ Familiar with AIAA and SAWE mass properties engineering standards. | <ul style="list-style-type: none"> ▪ Competent in calculating the mass properties, including assembly summations. ▪ Expertise in mass properties analysis and verification. ▪ Able to develop complex software calculation tools. Able to provide technical direction and train junior engineers in mass properties analysis skills and tools. ▪ Able to perform complex mass properties estimation of preliminary design concepts, modeling and analysis, reporting, and verification and model validation. ▪ Understands mass properties interactions of other mechanical analysis groups including stress, structural loads and dynamics, thermodynamics, aerodynamics, propulsion and power systems, as well as subsystem designers to promote mass properties efficient design alternatives. ▪ Able to develop and document requirements flow-down based on program performance requirements. ▪ Able to develop mass properties support requirements and schedules for the program. | <ul style="list-style-type: none"> ▪ Demonstrate complete expertise in the mass properties field. |



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| Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
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| Missiles & Space Pat Borden Technical Skills— Communications | <ul style="list-style-type: none"> ▪ Competent verbal and written communication skills. | <ul style="list-style-type: none"> ▪ Proper verbal and written communication skills to the level of program management. | <ul style="list-style-type: none"> ▪ Outstanding verbal and written communication skills to all levels of program and management. |
| Missiles & Space Pat Borden Technical Skills— Leadership | <ul style="list-style-type: none"> ▪ Participate and interact with other engineers to investigate and promote more mass properties efficient designs. ▪ Participate as fully competent and teachable mass properties team member of a program, taking ownership of small areas of technical activity. | <ul style="list-style-type: none"> ▪ Train junior engineers in mass properties analysis skills and tools and provide technical direction. ▪ Supervise junior engineers in ever-increasing complex mass properties analysis and verification skills. ▪ Train junior mass properties engineers to promote mass properties efficient designs. ▪ Supervise and support mass properties engineers to promote mass properties efficient designs. ▪ Lead and oversee the mass properties effort of a large program or several small programs. ▪ Support a multi-disciplinary team and solve program mass properties issues. | <ul style="list-style-type: none"> ▪ Coach, mentor, and train mass properties engineers in complex analysis and verification. ▪ Act as a technical consultant to programs and customers within the company, while supporting efforts to promote mass efficient designs. Support peer reviews when necessary. ▪ Lead and oversee the mass properties effort multiple large programs. ▪ Competently lead a multi-disciplinary team and solve complex program MP issues. |
| Missiles & Space Pat Borden Standards & Processes | <ul style="list-style-type: none"> ▪ Familiar with mass properties verification methods and the maintenance, calibration, and the operations of measurement instruments like platform scales, load cells and moment tables. ▪ Familiar with Mass Properties Engineering standards and Mass Properties Control processes and documentation. | <ul style="list-style-type: none"> ▪ Understand all mass properties verification methods and techniques. ▪ Develop complex mass properties verification methods, including static and dynamic balance measurement instruments. ▪ Develop new and innovative mass properties tools and techniques. ▪ Completely understands Mass Properties Engineering standards and Mass Properties Control process, with ability to modify and streamline standards and process where applicable. | <ul style="list-style-type: none"> ▪ Develop new and innovative mass properties tools and techniques in analysis, verification, and control. ▪ Develop new industry-wide mass properties engineering standards and control processes. |



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| Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|--|--|---|---|
| Missiles & Space Pat Borden MPE Specific Job Duties | <ul style="list-style-type: none"> • Estimate and/or calculate mass properties, including mass, 3-axis center of mass, moments of inertia, and products of inertia. • Create and update mass properties model using relevant design data along with the estimated or calculated mass properties. • Perform simple and/or basic trade studies. • Prepare and publish reports, graphs and visual presentation aids. • Perform simple and/or basic mass properties measurements, including minor piece parts and subassemblies where results are not critical. • Interpret measurement data into final user values using data reduction analysis. • Support mass properties requirement derivation. • Support Mass Properties Control Boards. • Document and publish analysis reports, memos, and other reference material. • Successful completion of the SAWE Associate Mass Properties Engineer (AMPE) test. | <ul style="list-style-type: none"> • All AMPE duties, plus the following: • Create and make presentations at program design reviews. • Lead mass properties audits, with program and customer visibility. • Develop test procedures, coordinating with other engineering groups to acquire proper data while managing complex interfaces. • Perform complex mass properties measurements, including major assemblies where results are critical. • Facilitate Mass Properties Control Boards and weight reduction teams. • Lead mass properties efforts on small to large programs. • Supervising mass properties functions. • Determine tasks, priorities, and schedule work on programs. • Work with integrated product teams and interact with many other engineers, technicians, subcontractors, and customer on programs. • Interface with senior program and customer management, including advising on critical technical issues and their relationship to technical and programmatic performance. • Successful completion of the SAWE Certified Mass Properties Engineer (CMPE) test. | <ul style="list-style-type: none"> • All CMPE duties, plus the following: • Subject Matter Expert on everything relating to Mass Properties Engineering; researching as necessary to ensure appropriate knowledge to implement proper processes. • Mentor other mass properties engineers to improve mass properties knowledge and ensure their success. • Lead mass properties audits, with senior management and customer visibility. • Lead mass properties efforts on large programs critical to business success, typically on a high-visibility and customer-focused programs. • Ensure mass properties functions are carried out through other senior mass properties engineers. • Maintain discipline and handle personnel issues of mass properties support team. • Provide technical direction to program management and customer to ensure programmatic performance. • Successful completion of the SAWE Expert Mass Properties Engineer (EMPE) test. |
| Missiles & Space Sys | 1. Basic Fundamentals | Engineer <ul style="list-style-type: none"> • Weight Estimating—New Studies, Advanced Design, Separate Project | Supervision of a Group <ul style="list-style-type: none"> • Detail Knowledge of Project • Weight Estimating—New Design |



| Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|---------------------------------|---|---|---|
| <p>Robert Zimmermann</p> | <p>Handle All Types of Weight Records</p> <p>Calculation Sheets</p> <p>Control Books</p> <p>Change Records</p> <p>Check and Record DCN's</p> <p>Contract Changes</p> <p>b. Calculate Drawings</p> <p>More Complicated Shapes</p> <p>Standard Section Areas</p> <p>Simple Layouts</p> <p>Pick up Drawing Errors</p> <p>Balance Assemblies to Determine CG</p> <p>Know Where to Look for Weights of items Not in Weight Records</p> <p>Weighing Procedure and Care of Equipment</p> <p>Location of Project in Shop for Weighing of Small Parts and Assemblies</p> <p>Proper Use and Care of Equipment, Equipment Check Lists</p> <p>d. Accomplished Copy Checker</p> <p>Working Knowledge of:</p> <p>Coding—How and Why</p> | <ul style="list-style-type: none"> • Promote Weight Control—Spot Problem Areas and Push Light Weight Design • Familiarity and Latest Design and Fabrication Methods and Their Effect on Weight • Preparation of Weight Reports—Estimated, Estimated, Calculated, Actual, Status, Pre Flight, Post Flight, Loads Data Book, Performance Report Inputs. • Supervision and Instruction of Junior Personnel <ul style="list-style-type: none"> 2. Working Knowledge of: <ul style="list-style-type: none"> a. Detail Project Specifications <ul style="list-style-type: none"> 1. Their Effect on Weight b. Moment of Inertia <ul style="list-style-type: none"> 1. Quick Estimate Methods 2. Special Breakdowns e. Trouble Shooting Problem Areas and Obtaining Satisfactory Results d. Details of Project <ul style="list-style-type: none"> 1. Design Criteria, Performance, etc. 2. Effect of Weight on the Project e. Use of All Denver Division Mass Properties Equipment f. Detail Knowledge of M/P Computer Programs g. Statistical and Error Analysis h. Range Safety Analysis i. Launch Drift Analysis j. Mechanized Loads Cycle <ul style="list-style-type: none"> 1. Concentrated & Distributed Mass Matrix 2. Volume and Head Data 3. In flight A. SEN Mass Matrix 5. BCD/Binary Conversion k. Separation Analysis: <ul style="list-style-type: none"> Stage/Step, Fairing, Payload <ul style="list-style-type: none"> 1. Actual Fairing Weighing Procedure (ETR) m. Mass Properties 9 Co-Sine Transformation n. ETR/WTR Launch Operations Support 3. Familiarity With: | <ul style="list-style-type: none"> • Promote Weight Control • Anticipate New Problems <p>Working Knowledge of:</p> <ul style="list-style-type: none"> • Preparation and Use of Statistical Data for Weight Estimating and Control • Problem Areas of a Job and Double Check Procedures <p>Anticipate Results</p> <ul style="list-style-type: none"> • Where and How to Push Weight Saving Ideas <p>Familiarity With:</p> <ul style="list-style-type: none"> • Customer Requirements for Wt. Information (Preparation and Submittal of) • Company Procedures • Complete Technical Knowledge of Mass Properties • Standard Procedure 99.12 – Mass Properties Verification (Options One and To) • M 71-2 Mass Properties Verification Practice <ul style="list-style-type: none"> I Summary Verification Practice II Single Axis C.G.—25 lb. Capacity III Single Axis C.G.—250 lb Capacity IV Universal Weight and Center of Gravity Table V Universal Portable Load Cell Weighing System VI MRC/MARK VII – 16 Mass Properties Measuring VII BLH Precision Portable Load Cell Weighing System <ul style="list-style-type: none"> • DBEE & DBEN Mass Properties System – Functional System Design • Operating Procedure Adapter Kit, Space Launch Vehicle, Weighing Set (BLH) • Operating Procedure Universal Portable Load Cell Weighing System – LV Application (TYCO) |



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| Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|-------|--|--|---|
| | <p>Weight Reports and Weight Control Charts</p> <p>How Data is Obtained for Each Reason for Each</p> <p>Preparation of Group and Detail Weight Statements</p> <p>Preparation of Graphs</p> <p>Familiarity With:</p> <p>Specifications</p> <p>Weight Control Procedure</p> <p>Light Materials</p> <p>Light Design Methods</p> <p>Type of Information in Design Data Book</p> <p>How to Prepare Graphs Properly</p> <p>Dead Weight</p> <p>Center of Gravity</p> <p>Moment of Inertia</p> <p>Weight History</p> <p>Associate Engineers</p> <p>Basic Fundamentals:</p> <p>a. Weigh Estimating</p> <p>From Layouts</p> | <p>a. Work Plans and Manpower Preparation SOW, EDGS, ICS Preparation</p> | |



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| | <p>From Marked-up Drawings</p> <p>From Stress Advance Information</p> <p>Allowances for Parts Not Shown</p> <p>Proper Factors for Parts Shown</p> <p>b. Complete Knowledge of Coding Procedure</p> <p>e. Actual Weighings</p> <p>Prepare and Use Check List</p> <p>Set up Scales</p> <p>Take Readings and Measurements</p> <p>Compute Results</p> <p>d. Instruct Junior Weight Engineers and Summer Hires</p> <p>Thorough and Complete Instructions</p> <p>Cooperative Attitude Toward Them</p> <p>e. Weight Specifications</p> <p>Knowledge and Use of:</p> <p>MIL-M-38310 (Latest Supp.) Mass Properties Control Requirements for Missile and Space Vehicles.</p> <p>SAMS0-STD-74-3 Titan III SLVS Mass Properties Requirements</p> <p>S-320-G-1 Supp. B. Handbook for Mass Property Measurements and Control—NASA</p> | | |



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|-------|---|---|---|
| | <p>—Goddard Space Flight Center, NASA Mass Properties Requirement Documents</p> <p>2. — Working Knowledge of:</p> <p>a. Preparation of Weight Reports Specification</p> <p>Group and Detail Weight Statements</p> <p>Balance Data for Weight Statements</p> <p>Adjust Actual Weighing to Weight Empty</p> <p>Special Balance Conditions</p> <p>Contract Changes</p> <p>GFE Variation;</p> <p>Contract Guarantee Comparison</p> <p>Changes Between Articles</p> <p>Status Reports—Quarterly, Pre Flight, Post Flight</p> <p>Performance Reports</p> <p>b. Weight Control Procedure</p> <p>Past and New Design Practice</p> <p>Weight Control Committee</p> <p>Use of Schedules in Determining When Item is Due</p> <p>Weight Control Propaganda</p> <p>Effect of Weight Saving on End Result (Cost \$/LB)</p> | | |



| Title | AMPE Associate Mass Properties Engineer | PMPE Professional Mass Properties Engineer | EMPE Expert Mass Properties Engineer |
|-------|--|---|---|
| | <p>e. Preparation of Usable Weight Studies</p> <p>Comparisons</p> <p>Progress Reports</p> <p>d. Preparation of Usable Graphs</p> <p>Dry Weight</p> <p>Center of Gravity</p> <p>Moment of Inertia</p> <p>Weight Comparisons</p> <p>Mass Distribution</p> <p>Familiarity With:</p> <p>a. Moment of Inertia</p> <p>Detail Calculations</p> <p>Quick Estimate Methods</p> <p>Presentation in Proper Form</p> <p>b. Specifications Affecting His Project</p> <p>e. Mechanics and Strength of Materials</p> <p>Physical Characteristics of Various Materials</p> <p>d. Stress Analysis Method</p> <p>Factors and Margins of Safety Used</p> <p>Weight Non-Optimum Factors</p> <p>e. Weight Histories</p> <p>Reasons for and Information Included</p> | | |



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| | Collect and Present Information in Proper Form f. Calculation of Static and Dynamic Balance Data Form to be Used Necessary Subdivisions Presentation of Results 4, Actual Balance Verification | | |
| Offshore 1 | | Need endorsement or recognition of the oil companies and contractors might like it, because it would eliminate risk of the critical engineering function. That is they could hire knowledgeable people. | |
| Offshore 2 | | Need to make it easy for a part time MPE lead to qualify. (Project Engineer, Discipline manager) Ranging from Project Engineers through engineer | |
| Offshore 3 | | Understanding of ISO 19905 and the difference of requirement for each risk class. | |
| Offshore 3 | | TLP CoG diagram, use development etc | |
| Offshore 4 | | Risk assessment and management | |
| Offshore 5 | <ol style="list-style-type: none"> 1. Hydrostatic based draft calculations 2. HVAC, weapon systems, hotel, cargo 3. Materials 4. Weight Reduction calculations, 5. know the Offshore training class and RPs | <ol style="list-style-type: none"> 1. Describe a Vendor weight control plan 2. Be able to identify and use 10 of the 14 weight estimating methods defined in the RPs (14 and C-09)- 3. Add Requirement 6 Validation (weighing) 4. Describe weighing of a small vs large object (40 oz vs 40,000 tons) | Derive a Bill of Materials from a concept level weight estimate. |

| M&S General | AMPE | CMPE | EMPE |
|------------------------------|---|---|--|
| <i>Discretion / Latitude</i> | <ul style="list-style-type: none"> • Applies discretion and judgment to complete assignments of moderate scope and complexity. | <ul style="list-style-type: none"> • Independently determines and develops approach to solutions, performing work without appreciable direction. | <ul style="list-style-type: none"> • Works under consultative direction towards predetermined long-range goals and objectives, acting independently to uncover and resolve issues |



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| M&S General | <u>AMPE</u> | <u>CMPE</u> | <u>EMPE</u> |
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| | <ul style="list-style-type: none"> • Works under very general supervision, usually by a Lead Mass Properties Engineer, and must be able to follow specific, detailed instructions. • Work is reviewed for soundness of technical judgment and overall adequacy. | <ul style="list-style-type: none"> • Exercises considerable latitude in determining technical objectives and approaches to assignment. • Work is reviewed upon completion for adequacy in meeting objectives and from a relatively long-term perspective for desired results. | <p>associated with the development and implementation of operational programs.</p> <ul style="list-style-type: none"> • Assignments are often self-initiated, determining and pursuing courses of action necessary to obtain desired results. Plans research & development programs and recommends technological application programs to accomplish long-range objectives. • Work is checked only to the effectiveness of results obtained, typically requiring a long-term perspective. • Virtually self-supervisory. |
| <i>Impact</i> | <ul style="list-style-type: none"> • Contributes to the completion of milestones associated with specific projects. • Failure to achieve results or erroneous decisions or recommendations may cause delays in program schedules and may result in the allocation of additional resources. | <ul style="list-style-type: none"> • Guides the successful completion of major programs/projects and may function in a project leadership role. • Erroneous decisions or recommendations would typically result in serious program delays and considerable expenditure of resources along with failure to achieve major organizational objectives. | <ul style="list-style-type: none"> • Designs research and develops highly advanced new applications resulting in new products/business opportunities. • Erroneous decisions or recommendations would typically result in failure to achieve critical organizational objectives and affect the image of the organization's technological capability, along with having a long-term negative effect on organization's reputation and business, and financial posture. |
| <i>Knowledge</i> | <ul style="list-style-type: none"> • Frequently uses and applies technical standards, principles, theories, concepts, and techniques to complete assignments of moderate scope and complexity. | <ul style="list-style-type: none"> • Complete understanding and wide application of technical principles, theories and concepts, in the field. • Applies extensive technical expertise, and has full knowledge of other related disciplines. | <ul style="list-style-type: none"> • Exhibits an exceptional degree of ingenuity, creativity, and resourcefulness. • Applies and/or develops highly advanced technical technologies, scientific principles, techniques, theories and concepts. • Viewed as an expert within the field. |
| <i>Liaison</i> | <ul style="list-style-type: none"> • Contacts are primarily internal company contacts with infrequent inter-organizational and outside customer contacts on routine matters. | <ul style="list-style-type: none"> • Contacts are frequently inter-organizational and with outside customers. • Represents the organization as the prime technical contact on contracts and projects, providing solutions to difficult technical issues associated with specific projects. • Interacts with senior external personnel on significant technical matters often requiring coordination between organizations. | <ul style="list-style-type: none"> • Serves as organization spokesperson on advanced projects and/or programs and advises management and customers on advanced technical research studies and applications. • Consultant to top management in long-range planning concerning new or projected areas of technical research and advancements. • Prime external spokesperson for the company on highly significant matters relating to research, engineering matters, programs, and technical capabilities. |



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| M&S General | <u>AMPE</u> | <u>CMPE</u> | <u>EMPE</u> |
|----------------------------|---|--|--|
| | | | <ul style="list-style-type: none"> • Often instrumental in attracting and obtaining major new business. |
| <i>Problem Solving</i> | <ul style="list-style-type: none"> • Provides and/or develops solutions to a variety of technical problems of moderate scope and complexity. | <ul style="list-style-type: none"> • Develops and/or provides technical solutions to complex problems which require the regular use of ingenuity and creativity. Solutions are imaginative, thorough, and practicable, and consistent with organization objectives. | <ul style="list-style-type: none"> • Provides solutions which are highly innovative and ingenious on unusually complex technical problems. • Develops information which extends knowledge in a given field. • Information may form the basis of newly developed concepts, theories, and products. |
| <i>Typical Minimums</i> | <ul style="list-style-type: none"> • Bachelor's degree from an accredited college in an engineering/technical discipline, with 2 years of professional experience; or no experience required with a related Master's degree. • Considered experienced and emerging career level, but still a learner. | <ul style="list-style-type: none"> • Bachelor's degree from an accredited college in an engineering/technical discipline, with 9 years of professional experience; or 7 years of professional experience with a related Master's degree. • Considered an emerging authority. | <ul style="list-style-type: none"> • Bachelor's degree in an engineering/technical discipline from an accredited college in a related discipline, with 20 years or more of professional experience; or 18 years with a related Masters, or 15 years with a related PhD degree. • Considered an expert, authority in discipline, and viewed as the most senior authority in discipline. |

| M & S Technical | AMPE | CMPE | EMPE |
|--------------------------------|---|---|---|
| <i>General Skills</i> | <ul style="list-style-type: none"> • Familiar with drawing system; capable of reading and error-checking drawings, familiar with release and change procedures and specifications. • Interprets detailed designs from manufacturing drawings or standard modeling software tools. • Knowledge and some proficiency with Microsoft Word, Excel and Power Point, solid modeling applications, and other software tools. • Familiar with and perform basic mechanical analysis including statics, kinematics, error analysis, tolerance stack up, etc. | <ul style="list-style-type: none"> • Expert with standard tools and techniques including improvements and development. • Competent with Microsoft Word, Excel and Power Point, solid modeling applications, with an understanding of other software analysis tools. • Performs complex mechanical analysis including statics, kinematics, error analysis, tolerance stack up, etc. | <ul style="list-style-type: none"> • Oversight activities of engineers working with standard tools and techniques. • Competent with all communication applications as well as complete understanding of all analysis tools. • Competent in complex mechanical analysis including statics, kinematics, error analysis, tolerance stack up, etc. |
| <i>Communications</i> | <ul style="list-style-type: none"> • Competent verbal and written communication skills. | <ul style="list-style-type: none"> • Proper verbal and written communication skills to the level of program management. | <ul style="list-style-type: none"> • Outstanding verbal and written communication skills to all levels of program and management. |



| M & S Technical | AMPE | CMPE | EMPE |
|---|---|---|---|
| <i>Mass Properties Engineering Skills</i> | <ul style="list-style-type: none"> • Familiar with mass properties, reports, balance, model coding, standards / data books, and nomenclature. • Calculates mass properties (<i>mass, 3 axis centers of gravity, and moments of inertia</i>) of components and performs summation calculations into assemblies. • Understand quick estimate methods (<i>i.e. ROG</i>) and special breakdowns, including use of shapes and sections to calculate mass properties; researches all sources of data as required. • Understanding of mass properties concepts, able to perform calculations by hand, and develop simple software calculation tools. • Understanding of standard mass properties analysis concepts like transformations, rotations, mass distributions, and uncertainties; applies skills to preliminary design estimation. • Familiar with mass properties calculation tools. • Understand requirements flow-down and subsystem mass properties allocations. • Understand development of program SOW and cost quotes. • Familiar with AIAA and SAWE mass properties engineering standards. | <ul style="list-style-type: none"> • Competent in calculating and/or estimating all mass properties; use translations and rotations to determine assembly summations. • Expertise in mass properties analysis and verification. • Able to develop complex software calculation tools. Able to provide technical direction and train junior engineers in mass properties analysis skills and tools. • Able to perform complex mass properties estimation of preliminary design concepts, modeling and analysis, reporting, verification, and model validation. • Understands mass properties interactions of other mechanical analysis groups including stress, structural loads and dynamics, thermodynamics, aerodynamics, propulsion and power systems, as well as subsystem designers to promote mass properties efficient design alternatives. • Able to develop and document requirements flow-down based on program performance requirements. • Able to develop mass properties support requirements and schedules for the program, understanding the system impact of all mass properties. • Promote mass properties efficient designs; capable of identifying problem areas; familiar with fabrication methods and mass properties impacts. Determine effect of weight saving on end result (<i>cost: \$/lbm</i>) • Able to perform statistical and error analysis. • Familiar with range safety, launch drift, loads cycle, and separation analysis. | <ul style="list-style-type: none"> • Demonstrate complete expertise in the mass properties field. • Able to support new studies and advanced designs, using allowances and factors as appropriate. • May use statistical data for mass properties estimating and control while anticipating problematic areas. • Able to anticipate difficulties and review procedures for resolution; able to resolve successfully. • Able to identify and implement specific mass reductions to assure mission success. • Expert in company procedures. • Expert in mass properties verification and model validation, including capability of developing the verification plan, new procedures, and supporting complex measurements. • Able to perform dynamic balancing, including adjustment and verification of flight hardware, requiring determination of principal axis misalignment, principal inertia matrix, and direction cosine matrix. |
| <i>Leadership</i> | <ul style="list-style-type: none"> • Participate and interact with other engineers to investigate and promote more mass properties efficient designs. | <ul style="list-style-type: none"> • Train junior engineers in mass properties analysis skills and tools and provide technical direction. | <ul style="list-style-type: none"> • Coach, mentor, and train mass properties engineers in complex analysis and verification. |



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| M & S Technical | AMPE | CMPE | EMPE |
|----------------------------------|--|---|--|
| | <ul style="list-style-type: none"> Participate as fully-competent and teachable mass properties team member of a program, taking ownership of small areas of technical activity. | <ul style="list-style-type: none"> Supervise junior engineers in ever-increasing complex mass properties analysis and verification skills. Lead and oversee the mass properties effort of a large program or several small programs. Support a multi-disciplinary team and solve program mass properties issues. | <ul style="list-style-type: none"> Act as a technical consultant to programs and customers within the company, while supporting efforts to promote mass efficient designs. Support peer reviews when necessary. Lead and oversee the mass properties effort of multiple large programs. Competently lead a multi-disciplinary team and solve complex program MP issues. |
| <i>Standards & Processes</i> | <ul style="list-style-type: none"> Familiar with mass properties verification methods and the maintenance, calibration, and the operations of measurement instruments like platform scales, load cells and moment tables. Familiar with Mass Properties Engineering standards and Mass Properties Control processes and documentation. | <ul style="list-style-type: none"> Understand all mass properties verification methods and techniques. Develop complex mass properties verification methods, including static and dynamic balance measurement instruments. Develop new and innovative mass properties tools and techniques. Completely understands Mass Properties Engineering standards and Mass Properties Control process, with ability to modify and streamline standards and process where applicable. | <ul style="list-style-type: none"> Develop new and innovative mass properties tools and techniques in analysis, verification, and control. Develop new industry-wide mass properties engineering standards and control processes. |

| M & S M & S Specific | AMPE | CMPE | EMPE |
|--|--|--|---|
| <i>MPE Specific Job Duties</i> | <ul style="list-style-type: none"> Estimate and/or calculate mass properties, including mass, 3-axis center of mass, moments of inertia, and products of inertia. Create and update mass properties model using relevant design data along with the estimated or calculated mass properties. Document all calculations, changes, and effectivity. Perform simple and/or basic trade studies. Prepare and publish reports, critical comparisons, trend graphs and charts, histories, ECA, distribution, uncertainties, and visual presentation aids. | <ul style="list-style-type: none"> All AMPE duties, plus the following: Create and make presentations at program design reviews. Lead mass properties audits, with program and customer visibility. Develop test procedures, coordinating with other engineering groups to acquire proper data while managing complex interfaces. Perform complex mass properties measurements, including major assemblies where results are critical; performs static balancing to requirements, including adjustment and verification of flight hardware. | <ul style="list-style-type: none"> All CMPE duties, plus the following: Subject Matter Expert on everything relating to Mass Properties Engineering; researching as necessary to ensure appropriate knowledge to implement proper processes. Mentor other mass properties engineers to improve mass properties knowledge and ensure their success. Lead mass properties audits, with senior management and customer visibility. May lead a large group of mass properties engineers. |



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| M & S M & S Specific | AMPE | CMPE | EMPE |
|----------------------|---|--|--|
| | <ul style="list-style-type: none"> • Perform simple and/or basic mass properties measurements, including minor piece parts and subassemblies where results are not critical. • Interpret measurement data into final user values using data reduction analysis. • Support mass properties requirement derivation. • Support Mass Properties Control Boards. • Document and publish analysis reports, memos, and other reference material. • Successful completion of the SAWE Associate Mass Properties Engineer (AMPE) test. | <ul style="list-style-type: none"> • Facilitate Mass Properties Control Boards and weight reduction teams. • Lead mass properties efforts on small to large programs while supervising mass properties functions and determining tasks, priorities, and schedule. • Work with integrated product teams and interact with many other engineers, technicians, subcontractors, and customer on programs. • Interface with senior program and customer management, including advising on critical technical issues and their relationship to technical and programmatic performance. • Review all reports, including status, pre-flight, post-flight, design reviews, analysis cycles, performance reports, and data submittals. • Supports launch operations at range. • Successful completion of the SAWE Certified Mass Properties Engineer (CMPE) test. | <ul style="list-style-type: none"> • Lead mass properties efforts on large programs critical to business success, typically on a high-visibility and customer-focused programs. • Ensure mass properties functions are carried out through other senior mass properties engineers. • Maintain discipline and handle personnel issues of mass properties support team. • Provide technical direction to program management and customer to ensure programmatic performance. • Successful completion of the SAWE Expert Mass Properties Engineer (EMPE) test. |

Working



6 References & Revision history

6.1 References

SAWE Paper 1655 Training MPEs

SAWE Paper 3129 Ford Weight Engineering Academy

6.2 Revision History

| Who - When | Rev & Short description |
|---------------------|--|
| DY 5/29 | Rev. 0.00 - Initial issue |
| ARS 5/29 | Rev. 0.01 <ul style="list-style-type: none"> • Added numbers to the requirements • Added comment tables with some comments as examples • Simplified certification levels as discussed at the May meeting • Added revision history |
| ARS 5/39 | Rev. 0.02 Based on discussions with Damian <ul style="list-style-type: none"> • Added industry specific AMPE levels back into the figure in section 1.1 • Added Cross Industry to the choice of industry columns, • Added more notes on how to fill in the requirements tables |
| ARS 6/20 | Rev. 0.03 Added sections 5.1 & 5.2 i.e. Reference Section and two SAWE papers |
| ARS 6/23 | Rev. 0.04 <ul style="list-style-type: none"> • Added Section 1.3 Current Overall process • Added Section 1.4 Terms & Abbreviations • Added Section 4.1 thru 4.3 side by side comparisons, by General and industry specific • Added comments from David Tellet in Section 4 • Completed an affinity analysis of the requirements in section 4.2 to group requirements under 8 categories • Removed several changes (crossed out above) |
| ARS & DY 6/30 | Rev. 0.05 <ul style="list-style-type: none"> • Edited sections 1.2, 1.3, 1.4, 3.0 and 4.0 to include Damian's edits to Rev 0.04 (all except renumbering the outline of requirements, which were not discussed) • Added a description of the limitations of MPE levels to Section 2 • Added title page, with copyright and export control notice in the footer • Added Section 5, "Collection of Certification level views" which changed the old section 5 to Section 6 References and Revision History. |
| ARS 7/2 | Rev 0.06 <ul style="list-style-type: none"> • Section 4.2 - Added the Offshore requirements items 1.62, 1.63 • Section 4.3 - Added Offshore requirements 1-4 • Section 5.2 - Corrected some views authorship, reference etc. |
| ARS 7/12 | Rev 0.07 <ul style="list-style-type: none"> • Section 5.2 - Added David Tellet's views on levels. • Section 4.2 – cleaned up requirements 5.1, by Andy Schuster • July 11th mtg changes <ul style="list-style-type: none"> ▪ Section 5.2 expended Evan Vekris's definitions ▪ Section 4.2 expanded requirements 1.60 and 2.0 |



| Who - When | Rev & Short description |
|-----------------|---|
| ARS 8/13/19 | Rev. 0.08 <ul style="list-style-type: none"> • Incorporated changes from the July 14th Subcommittee meeting • Added Bell Lee's 4.3 Verification requirements to Section 5.2 • Added Paul Kennedy's Measurement requirements based on papers 2140 2535 in sections 4.4 & 4.5 added possible contribution by Space Electronics. • Added Robert Zimmerman's Missile & Space requirements to section 4.3. Omitted the Summer Hire requirements and combined the Associate and Junior Engineer requirements into the Associate MPE category. Eliminated company references or made those generic. • Changed Certified MPE to Professional MPE throughout - John Hargrave's request |
| ARS 9/10/19 | Rev. 0.09 <ul style="list-style-type: none"> • Added David Tellet's 8.0 to section 4.2 • Added Pat Borden's Missiles & Space requirement to section 4.3 • Change Certified to Professional as in Professional MPE vs Certified MPE • Added Andy Schuster's section 7 and 10 to section 4.2 • Add Bell Lee's item 9.0 in section 4.2 |
| ARS 10/9/19 | Rev 0.10 Change Document number to CA-01,2019 Moved comments to CA-99,2019 |
| ARS 10/12/19 | Rev 0.11 Revised SAWE Address on Cover Page Based on Robert Zimmerman's comments: <ul style="list-style-type: none"> • Revised WCP definition to limit it to the marine and offshore industry, • Deleted from the MPCP definition a cross references to WCP • Expanded MPE definition to include MP Engineer and Engineering • Deleted SMPE definition because it was nonsensical, and not used in the document • Added to the first sentence in section 3.1 "but rather focused on the common and shared knowledge of Mass Properties Engineering." |
| ARS 10/23/19 | Rev 0.12 Added Giorgio Previati's Software comments to section 7.0 |
| ARS 11/15/19 | Rev. 0.13 Added Andrew Walker's Validation requirement to section 4.2.2 Changed Andy Schuster's Validation requirement to section number 4.2.1 from 4.2 |
| ARS 1/26/20 | Rev. 0.14 Revised Section 5.0, Missile & Space industry specific requirement consolidated by Pat Bordon and Robert Zimmerman. Deleted previous section 5.0 Missile & Space industry specific requirements |