Physical Sciences

Spill-Resistant Alkali-Metal-Vapor Dispenser

This dispenser can be used in a gravitational or non-gravitational environment.

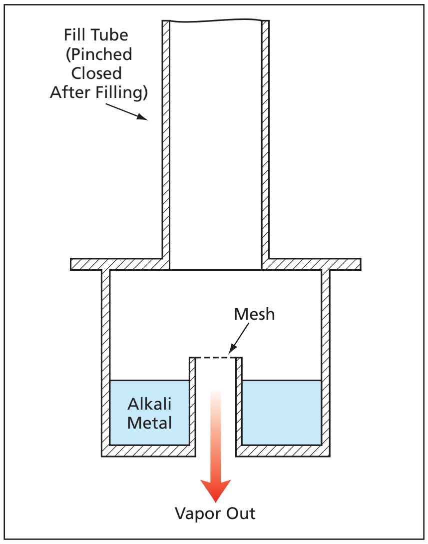
NASA's Jet Propulsion Laboratory, Pasadena, California

A spill-resistant vessel has been developed for dispensing an alkali-metal vapor. Vapors of alkali metals (most commonly, cesium or rubidium, both of which melt at temperatures slightly above room temperature) are needed for atomic frequency standards, experiments in spectroscopy, and experiments in laser cooling. Although the present spill-resistant alkali-metal dispenser was originally intended for use in the low-gravity environment of outer space, it can also be used in normal Earth gravitation: indeed, its utility as a vapor source was confirmed by use of cesium in a ground apparatus.

The vessel is made of copper. It consists of an assembly of cylinders and flanges, shown in the figure. The uppermost cylinder is a fill tube. Initially, the vessel is evacuated, the alkali metal charge is distilled into the bottom of the vessel, and then the fill tube is pinched closed to form a vacuum seal.

The innermost cylinder serves as the outlet for the vapor, yet prevents spilling by protruding above the surface of the alkali metal, no matter which way or how far the vessel is tilted. In the event (unlikely in normal Earth gravitation) that any drops of molten alkali metal have been shaken loose by vibration and are floating freely, a mesh cap on top of the inner cylinder prevents the drops from drifting out with the vapor. Liquid containment of the equivalent of 1.2 grams of cesium was confirmed for all orientations with rubbing alcohol in one of the prototypes later used with cesium.

This work was done by William Klipstein of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1). NPO-40481*



Molten Alkali Metal (or any other liquid, for that matter) does not pass through the outlet, no matter which way the vessel is tilted.

A Methodology for Quantifying Certain Design Requirements During the Design Phase

Requirements for safety, reliability, and maintainability are developed and balanced.

John F. Kennedy Space Center, Florida

A methodology for developing and balancing quantitative design requirements for safety, reliability, and maintainability has been proposed. Conceived as the basis of a more rational approach to the design of spacecraft, the methodology would also be applicable to the design of automobiles, washing machines, television receivers, or almost any other commercial product.

Heretofore, it has been common practice to start by determining the requirements for reliability of elements of a spacecraft or other system to ensure a given design life for the system. Next, safety requirements are determined by assessing the total reliability of the system and adding redundant components and subsystems necessary to attain safety goals. As thus described, common practice leaves the maintainability burden to fall to chance; therefore, there is no control of recurring costs or of the responsiveness of the system. The means that have been used in assessing maintainability have been oriented toward determining the logistical sparing of components so that the components are available when needed.

The process established for developing and balancing quantitative requirements for safety (S), reliability (R), and maintainability (M) derives and integrates NASA's top-level safety requirements and the controls needed to obtain program key objectives for safety and recurring cost (see figure). Being quantitative, the process conveniently uses common mathematical models. Even though the process is shown as being worked from the top down, it can also be worked from the bottom up.

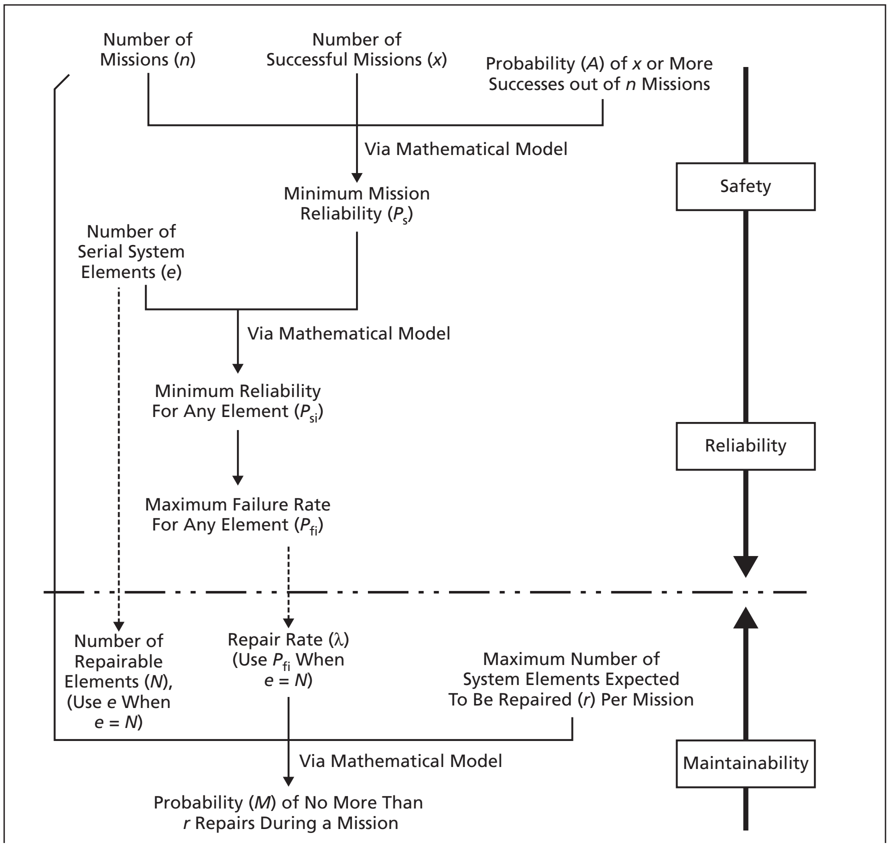
This process uses three math models: (1) the binomial distribution (greater-than-or-equal-to case), (2) reliability for a series system, and (3) the Poisson distribution (less-than-or-equal-to case). The zero-fail case for the binomial distribution approximates the commonly known exponential distribution or "constant failure rate" distribution. Either model can be used. The binomial distribution was selected for modeling flexibility because it conveniently addresses both the zero-fail and failure cases. The failure case is typically used for unmanned spacecraft as with missiles.

As the first step of the process, the systems engineering designer begins with three inputs: (1) the desired number of missions the program is planning (n); (2) the minimum number of successful missions for duration of the program (x); and (3) the assurance (A) of obtaining x or more successes out of the n missions. In risk terms, $1 - A$ is the probability or likelihood of not obtaining *x* or more successes out of *n* number of attempts or not obtaining the desired level of safety and reliability over the life of the system's program. When these three inputs are used in the binomial distribution, the minimum mission reliability (P_s) is calculated. At this point of the process, NASA's top-level safety requirement has been established.

The second step uses the minimum mission reliability (P_s) and an estimate of the number of serial line replaceable unit (LRU) elements (e) as inputs into the formula for reliability of a series system to calculate minimum element reliability (P_{si}). Maximum element failure rate (P_{fi}) is equal to $1 - P_{fi}$. Without considering the maintainability burden, which has a very large influence on recurring cost including the system's acquisition (fleet) size, the process at this point has established the safety and reliability requirements for the program.

The last step addresses the maintainability parameter, the parameter that provides a control for recurring costs resulting from maintenance and repair. Similar to assurance or program reliability (A), program maintainability (M) is a probability. The probability M is determined by the Poisson distribution and uses the following inputs: (1) the number of missions (n), (2) the number of elements (N, where $e \leq N$), (3) the LRU failure rate (P_{fi} or λ, where $\lambda \leq P_{fi}$), and (4) the maximum number of LRU repairs (r). Technically, M is the probability of no more than r number of repairs occurring at a particular mission using e number of LRUs with an average failure rate of P_{fi} or λ.

To achieve the desired results in both M and the desired A, adjustments in e, P_{fi}, N, and λ must be made. These values become the enabling requirements to balance and achieve the desired key objectives of the program.



The **Process Described in the Text** can be run from the top down or from the bottom up as represented in this diagram.

This work was done by Timothy Adams and Russel Rhodes of **Kennedy Space Center**. *For further information, contact Timothy Adams at (321) 867-2267.*
KSC-12567

Measuring Two Key Parameters of H3 Color Centers in Diamond

These parameters are needed for the further development of diamond lasers.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of measuring two key parameters of H3 color centers in diamond has been created as part of a continuing effort to develop tunable, continuous-wave, visible lasers that would utilize diamond as the lasing medium. (An H3 color center in a diamond crystal lattice comprises two nitrogen atoms substituted for two carbon atoms bonded to a third carbon atom. H3 color centers can be induced artificially; they also occur naturally. If present in sufficient density, they impart a yellow hue.) The method may also be applicable to the corresponding parameters of other candidate lasing media. One of the parameters is the number density of color centers, which is needed for designing an efficient laser. The other parameter is an optical-absorption cross section, which, as explained below, is needed for determining the number density.

The present method represents an improvement over prior methods in which optical-absorption measurements have been used to determine absorption cross sections or number densities. Heretofore, in order to determine a number density from such measurements, it has been necessary to know the applicable absorption cross section; alternatively, to determine the absorption cross section from such measurements, it has been necessary to know the number density. If, as in this case, both the number density and the absorption cross section are initially unknown, then it is impossible to determine either parameter in the absence of additional information.

In the present method, the needed additional information is extracted from the saturation characteristics of the bulk material: As a laser gain medium (in this case, diamond) absorbs