NEW ENGLAND
HOSPITAL ENGINEERS SOCIETY
NEWSLETTER

JULY 1986

NOTE FROM THE EDITOR

Jim Lawson has been nominated for President-Elect of the American Society for Hospital Engineering. Those of us whom have known Jim over the years and have been direct recipients of his activities in N.E.H.E.S. and A.S.H.E. feel a strong show of support — for his election is well earned.

Please review Jim’s biography and the short interview of last month.

Jack Gosselin, Editor
Chairman for Essex Junction Troop 24, Boy Scouts of America. Committee member for 10 years.

Family Status: Married to Carole for 36 years. One married son and one married daughter. 5 grandchildren.

Personal Interests or Hobbies: Loafing, Puttering, Walking. Touring rural areas and small towns. Watching railroad trains go by.

Considering the rapid advancement in the professional role of the hospital engineer in the last 20 years, what do you feel the next 20 years will bring for the discipline?

I doubt that anyone can realistically forecast much of anything beyond the next five years. However, I believe that the overall 5 year rate of change in the role of the professional hospital engineer has been about the same over the last 20 years and that the 5 year rate of change will continue for the next 20 years.

As many ‘chief engineers’ advance by necessity into more administratively responsible roles, how do you think this will impact the field as a whole?

It is usually only the initiative and commitment of the individual that either enables or impedes the growth of any individual within any particular organization.

I believe that the roles of future hospital professionals will stress versatility of skills rather than specialization of skill.

What are your personal thoughts in regards to educational opportunities for the hospital engineer in relation to other career paths?

Hospital Engineering is a very complex, dynamic field. It also offers relatively few new annual job opportunities. As a result, Educational Institutions are not interested in developing graduate programs for hospital engineers.

The best educational opportunities for the hospital engineer are therefore available through the seminars, publications, and other resources of societies like the American Society for Hospital Engineering, The New England Hospital Engineers Society, The New England Hospital Telecommunication Association, or an active state or local Hospital Engineering Group.

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JAMES M. LAWSON

Position: Administrative Engineer, Medical Center Hospital of Vermont, Burlington, VT.

Education: Milwaukee School of Engineering; Refrigeration, Heating, Air Conditioning, Associate Degree.

Experience: Three years as Field Service Engineer for a national manufacturer of heating and air conditioning equipment (New York and Northeast Region); six years as Project Engineer for a mechanical contractor (Vermont and Northern New York); twenty-four years as Hospital Engineer (Medical Center Hospital of Vermont).

Professional Affiliation: Region 1 representative of the ASHE Board (4 yrs.). Member and Fellow of the American Society for Hospital Engineers Society; Charter Member of the Vermont Hospital Engineering Society; Member of the National Association of Power Engineers; Licensed Chief Engineer, Examiner, and Instructor for the National Institute for Uniform Licensing and Power Engineers.

Civic Affiliations: Past Committee
REPORT PRESENTED TO N.E.H.E.S. BOARD MEETING
JUNE 8th 1986
of attendance at n.f.p.a. annual meeting, atlanta, georgia
May 19 - 22, 1986

The main purpose of this 90th Annual Meeting was the review of twenty-eight (28) N.F.P.A. Codes and Standards by the various N.F.P.A. technical committees. During the Technical Committee Report Session on Wednesday, May 21st a full presentation was made of each code and standard together with proposed modifications and a vote was taken to either accept or reject the amended or new standards.

My purpose for attending this particular meeting was to participate in the discussions of the various proposed changes and amendments to codes and standards which had a direct or indirect effect on the Health Care Industry. Prior to the Technical Committee Report Session on Wednesday, I attended various technical committee discussions with the Health Care Section (HCS) of the N.F.P.A.

CODES AND STANDARDS REVIEWED BY THE HCS

The following codes and standards were reviewed by the HCS:

Documents:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Review Committee</th>
</tr>
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<tbody>
<tr>
<td>NFPA 70</td>
<td>National Electrical Code</td>
<td>Entire Committee</td>
</tr>
<tr>
<td>NFPA 80</td>
<td>Fire Doors and Windows</td>
<td>Bernie Kinlock, Bill O'Day, Bill Alman</td>
</tr>
<tr>
<td>NFPA 80A</td>
<td>Protection of Buildings from Exterior Fire Exposure</td>
<td>Tom Mattern, Bob Agnello</td>
</tr>
<tr>
<td>NFPA 45</td>
<td>Laboratories Using Chemicals</td>
<td>Chuck O'Day, Kirby Perry</td>
</tr>
<tr>
<td>NFPA 75</td>
<td>Electronic Computer Equipment</td>
<td>Bill O'Day, Tom Mattern</td>
</tr>
<tr>
<td>NFPA 171 (New)</td>
<td>Visual Alerting Systems for General Public Safety</td>
<td>B. Blount, Tom Mattern</td>
</tr>
<tr>
<td>NFPA 78</td>
<td>Lighting Protection Code</td>
<td>B. Blount, Jim McDowell</td>
</tr>
<tr>
<td>NFPA 600</td>
<td>Private Fire Brigades</td>
<td>Jim McDowell, Tom Mattern</td>
</tr>
<tr>
<td>NFPA 20</td>
<td>Centrifugal Fire Pumps</td>
<td>Jim McDowell, Tom Mattern</td>
</tr>
<tr>
<td>NFPA 901</td>
<td>Uniform Coding for Fire Protection</td>
<td>Tom Jaeger, Dick Strub</td>
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Several HCS Committee meetings were conducted prior to the main Technical Committee Report Session when the voting took place. During these HCS meetings much discussion was held in particular regarding the many changes being proposed to N.F.P.A. 70 — National Electrical Code. The meetings were attended by both Health Care Industry personnel (Hospital Engineers, Consultants, etc.) and by members of the N.F.P.A. National Electrical Code Committees. This produced some "vigorously" discussed and debated and sometimes outright disagreement. However, it was at least constructive and clearly demonstrated the necessity for an increase in the attendance by Hospital Engineer members.

RESULTS OF VOTING ON CODES AND STANDARDS

The Technical Committee Report Session extended over a continuous period from 1:00 PM to about 8:00 PM on Wednesday, May 21, 1986, during which time full presentations were made on all changes/modifications to codes and standards. In addition opportunity was given to the full voting N.F.P.A. members to make a verbal presentation to support or criticize any new standards. The following briefly summarizes the more important comments made and the results of voting on codes and standards which directly affect the Health Care Industry.

- NFPA 80: Fire doors and windows — ACCEPTED
- NFPA 80A: Protection of Buildings from Exterior Fire Exposure — ACCEPTED
- NFPA 45: Laboratory Using Chemicals — ACCEPTED
- NFPA 75: Electronic Computer Equipment — RETURNED TO COMM.
- NFPA 171: Visual Alerting Systems for General Public Safety — ACCEPTED
- NFPA 78: Lighting Protection Code — ACCEPTED
- NFPA 600: Private Fire Brigades — ACCEPTED
- NFPA 20: Centrifugal Fire Pumps — NOT PRESENTED
- NFPA 901: Uniform Coding For Fire Protection — ACCEPTED

The most interesting discussions in the above were in respect to NFPA 75 — Electronic Computer Equipment. Presentation was made by an IBM representative who raised many objections to the proposed rule making. His presentation on documentation for these objections was very poor and greatly detracted from the opinions he was trying to express.

Most of his objections were rejected by committee vote; however, at the end of a long and tedious debate, a vote was taken to return this whole amended standard back to committee for a re-evaluation and drafting. One point of objection made during the discussions was related to the reclassification of the space under a raised floor in a computer room to that of "plenum". Had this been accepted, then we all would have to change the existing Pvc piping in our computer room to a fire rated teflon coated cable which is significantly more costly.

NATIONAL ELECTRICAL CODE — NFPA 70

This was the most important issue addressed at this meeting. The magnitude of the data under discussion resulted in a "Technical Committee Report" (TCR) document of 644 pages and a "Technical Committee Document" (TCD) of 480 pages, all of which dealt exclusively with the NFPA 70 amendments.

There were one hundred and eleven (111) articles of the existing code subjected to review and amendment. The technical committee with the responsibility to evaluate these amendments was divided into twenty (20) panels each with a Chairman and a voluntary staff of technically qualified people with experience in the required specific areas. In the appendix of this report are copies of the pages from the official documents showing the lists of articles, technical panels and names and affiliations of panel members. It is sad to say that I was unable to find any representation from the Health Care Industry amongst any of the panel membership.

The following summarizes the results of the voting on amendments which have a direct effect on the health care industry.

1. Ground Fault Protection. The proposal TCR 4-195, to permit hospitals to install ground fault indication in place of ground fault protection trips was defeated by 192 to 186 votes.

2. Non-Metallic Conduit. The proposal to permit the use of non-metallic tubing (plastic conduit) for electrical services was accepted by a large majority vote.

3. Hospital Grade Receptacles. The HCS made a gallant effort to overturn proposal TCR-17-156 and TCR 17-161 which require hospital grade (HG) receptacles in both general care and critical care patient areas. The results of the votes were:

- Proposal to use HG receptacles in both areas defeated - 164 against - 148 for.
- Proposal to use HG receptacles in critical care only - 115 against - 206 for.
This means that HG receptacles will be required only in Critical Care areas.

4. ISOLATED POWER SYSTEMS. This was not discussed in any detail and returned to the Committee due to a conflict of having two (2) NFPA standards in effect dealing with the same topic.

COMMENTS AND OBSERVATIONS

This was my first attendance at an NFPA meeting where voting members participated in the democratic process of deciding which codes and standards would be accepted. It was in itself, an experience and education to be a part of this process and observe the benefits of an open debate contrast with the obvious economic influence of the industry based lobby groups.

I was particularly disappointed to witness the defeat of proposal TCR 4-195 changing ground fault protection trip to GFP indicators. This proposal was defeated by only four (4) votes, the main opposition coming from the manufacturers of electrical equipment. The basis of the opposition was the protection of valuable electrical switchgear which was viewed to be more important than the potential risk to patients in critical care areas, where life may be dependent upon an uninterruptible electrical service. A GFP trip fitted to critical area electrical distribution panels may not cause the engineering power systems to operate unless specifically designated to do so. This aspect of the special circumstances existing in a hospital was not appreciated by the majority of voting members.

The debate on the proposal to accept the use of non metallic tubing for electrical services has been fought vigorously by the EMT manufacturers for many years and at last, common sense prevails.

The debate and resulting votes to reform NFPA - 75 e-ctronic computer systems, back to committee was particularly educational to me. When reviewing the published documents, I had missed the relevance of the changes of designation of the raised computer floor space to "plenum". Had this been accepted, it would have resulted in a requirement to use Teflon coated cable or metallic conduits for all services in the area. This debate also demonstrated the need to carefully plan any presentation made before committee and the value of working with groups such as the HCS.

The next hurdle we face is the universal acceptance of NFPA 99 - Health Care Facilities Standard, which will be presented at the NFPA Fall meeting. We should encourage all our members to obtain copies of this new standard and review it carefully. This could be the standard which we operate our facilities under in the future.

Peter Fovargue
NFPA Representative for NEHES
Danbury Hospital
Danbury, CT 06810

Predicting Staffing Requirements

By William A. Short, P.E., C.C.E.
Reprinted from Hospital Topics Nov./Dec. '85

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lant engineering managers, administrators, and plant consultants have often asked the question, "Can the staffing requirements for a maintenance department be predicted using some key, fixed statistics?" The point of the question is simple. That is, can some measurements of the working environment be used to calculate a theoretical staffing level for a maintenance department?

Generally speaking, much to the frustration of administrators, the answer has been no. The reasons for this were many, but the principal factors cited included:

1. The wide variety of ages of buildings.
2. The wide variety and condition of the plant equipment (generators, boilers, etc.)
3. The wide variety of management styles and capabilities of maintenance managers.
4. The tolerance (or lack of it) administration has for contracting for some maintenance responsibilities.

Only intuitive judgments, however, have ever been used to arrive at the conclusion that no "formula" exists which can be used to predict maintenance staffing. Other attempts at quantifying maintenance needs (Mori trend, for example) have been attempted, but still do not seem to provide reasonable predictions of maintenance staffing.

To attempt to discover if there can be some calculation between maintenance staffing and key hospital statistics, a statistical experiment was undertaken to determine whether a relationship could be established between staffing and some key indicators. The experiment consisted of gathering data from a broad sample of hospitals in the Southeast, making some adjustments for outside purchases of labor and non-maintenance activities, then testing for correlations between the indicators and the staffing. A discussion of the development of the dependent variable (adjusted paid hours) and the independent variables is presented later on.

The experiment tested for correlation between adjusted paid hours and the following, independent variables:

- number of beds
- tons of air conditioning
- boiler horsepower
- KWHR of electricity consumed per year
- age of the facility

About 160 hospitals in the Southeast were asked to provide this information about their facility. In addition, they were asked for information about the total paid hours in maintenance, the hours spent in renovation/construction, and the total costs of outside maintenance contracts. Adjustments for hours spent in non-maintenance activities and for hours purchased outside of the hospital (contract maintenance) were made in the total paid hours to bring everything into perspective for the different approaches to maintenance.

Of the 160 hospitals surveyed, 74 replied.

Continued next page
Their profiles are summarized below:

<table>
<thead>
<tr>
<th>INDEPENDENT VARIABLE</th>
<th>MIN.</th>
<th>MAX.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Beds</td>
<td>38</td>
<td>1300</td>
</tr>
<tr>
<td>Tons A/C</td>
<td>0</td>
<td>6500</td>
</tr>
<tr>
<td>Boiler HP</td>
<td>0</td>
<td>2200</td>
</tr>
<tr>
<td>KWHR Electricity/Year</td>
<td>810</td>
<td>120,000</td>
</tr>
<tr>
<td>Building Age (Years)</td>
<td>3.0</td>
<td>33.4</td>
</tr>
</tbody>
</table>

EXPERIMENTAL RESULTS

Upon application of a multiple linear regression analysis technique to the data, it was discovered that the model did not work for hospitals under 100 beds. There were 21 hospitals in the model that were under 100 beds, so these were removed from the data base. Examination of the data from these 21 hospitals showed that the independent variables (number of beds, tons of air conditioning, etc.) covered such wide ranges that a statistically valid correlation between staffing and any of these independent variables was not possible.

The reason for this difficulty is that the smaller hospitals operate in a much different environment than their larger counterparts and must find unusual ways to deal with their various maintenance needs given that they usually have extremely limited resources. For example, some of these hospitals bought their steam from other facilities.

In the 53 remaining hospitals, it was discovered that building age and the amount of electricity consumed per year had no statistically significant relationship to the hospital's staffing level. In addition, it was discovered that there was an inverse relationship between the boiler horsepower and the staffing. That is, the larger the boilers, the fewer the maintenance staff (all other factors held constant).

Finally, as might be expected, there was a statistically significant positive relationship between staffing, the tonnage of air conditioning, and the number of beds. That is, all other factors held constant, more staffing was needed as tonnage of air conditioning increased and as the number of beds increased. Specifically, the relationship between adjusted paid hours and the independent variables can be stated as:

\[
\text{APH} = 46.03 \times \text{NB} + 9.751 \times \text{TAC} - 6.785 \times \text{BHP} - 14507
\]

where APH / Adjusted paid hours

- NB / Number of beds
- TAC / Tons of air conditioning
- BHP / Boiler horsepower

This equation predicts that a 250-bed hospital with 850 tons of air conditioning and 400 boiler horsepower would likely have a maintenance staff of about 13 FTEs. (Full time employees). A 400-bed hospital with 2300 tons of air conditioning and 2100 boiler horsepower would likely have about 24 FTEs devoted to maintenance.

In examining the model, it is important to remember that the model assumes that no maintenance is contracted and that the maintenance staff is 100% devoted to maintenance and does no renovation or construction work. An adjustment to actual, total paid hours was made to compensate for this factor. Adjusted, paid hours were used as the dependent variable in the experiment. See the discussion on the development of adjusted paid hours for more information.

ANALYSIS OF ACTUAL DATA

The actual data submitted by the 53 hospitals larger than 100 beds was analyzed using the regression formula developed above. The amount of total staffing explained by the model is the best measure of its ability to predict staffing. In the case of the 53 hospitals of over 100 beds, the model predicted the staffing with a 4.7% error compared to the average staffing for all of the hospitals. This is an indicator that the model is a good predictor of staffing in these hospitals.

Individually, the differences in the predicted and the actual adjusted staffing varied from —60% to +394% with an average difference of 21%. Because of the manner in which adjustments were made to the actual paid hours to compensate for contract maintenance, there can be some error in the estimate of adjusted paid hours. For this reason, one can expect differences of up to about 50% to be reasonable. In those cases where there is an error greater than this percentage, there may be a significant cause to evaluate staffing in the maintenance department.

In cases where the difference between the adjusted paid hours and the predicted hours is greater than 50%, one should look at the independent variables as the first hint of the reason for the difference. If the hospital buys its steam or air conditioning (the A/C TONNAGE or the BOILER HORSEPOWER is 0), then it is likely that there will be a large difference in predicted versus actual staffing.

If the department is overstaffed in comparison to the model, it is likely that it is overstaffed in reality, since there should be fewer demands placed on maintenance due to the lack of equipment to be maintained (no boilers, for example).

If the department appears to be significantly understaffed, attention should be given to the condition of the building and the attitude of the manager and administration to maintenance. It is likely that there is a run-to-failure approach to maintenance.

DEVELOPMENT OF ADJUSTED PAID HOURS

One of the dependent variables requested in the survey was total paid hours. This number had to be adjusted in order to reflect the existence of two factors which cloud the true resource available for maintenance: the use of contract maintenance and the time spent in non-maintenance activities (particularly in renovation and construction).

It is clear from experience that many different approaches are possible in delivering maintenance services. For example, it is possible to operate a large hospital with a small maintenance staff if all of the maintenance is purchased or contracted. If this difference were not accounted for in the model, then the staffing predicted could be artificially low, since some of the individuals in the data base would show a lower staffing than is actually in place.

In addition, the total paid hours may contain a significant amount of non-maintenance work. The most obvious source of non-maintenance work is renovation and construction. It is clear from experience that many institutions devote a great deal of maintenance resources to renovation and construction. It was important in the linear regression model to remove the effect of this on the staffing.

In order to minimize the artificial differences created by these two problems, an adjustment was made to total paid hours. The survey also requested the total dollars devoted to outside maintenance of plant equipment. This amount was divided by 50 in order to give an estimate of the number of labor hours that are represented by the total contract maintenance cost. It was further assumed that these labor hours were used in addition to the in-house staff to do maintenance and were added to the total paid hours.

The survey also asked for an estimate of the total hours spent in renovation and construction. This amount of time was subtracted from the total paid hours to allow for the fact that some in-house maintenance resources are not used for maintenance (they are used for renovation and construction instead).

The adjustment is further explained in the example below:

**TOTAL PAID HOURS:** 32,000
**TOTAL RENOV./CONSTRUCTION:** 1,800
**TOTAL AVAILABLE HOURS:** 30,200
**TOTAL CONTRACT COST:** $5,000
**EQUIVALENT LABOR:** 100 HOURS
**NET LABOR USED:** 30,300 HOURS

This example represents the best way to account for these differences without going to extreme lengths to gather more accurate source data.

STATISTICAL METHODS

The method used to predict the staffing was a statistical tool called multiple linear regression which allows a set of related data to be analyzed in a search for predictable relationships among variables. It develops mathematical descriptions (linear equations) of the relationship between the dependent variable and the independent variables.

In addition, it describes how much of the variation in the dependent variable is explained by variations in the independent variables. Multiple linear regression analysis is a particularly useful tool in looking for cause and effect relationships when there are a number of independent variables at work on the dependent variable. It is a well-established technique described in a number of statistical texts.

For the hospitals larger than 100 beds, the actual study found that about 90% of the variation in the dependent variable (adjusted paid hours) could be explained by variation in three of the independent variables: patient beds, tonnage of air conditioning, and boiler
horsepower. There was no correlation between the adjusted paid hours and the KWHs of electricity consumed or the building age.

In the analysis of the small hospitals, it was found that only about 15% of the variation in the dependent variable could be explained by the variation in the independent variables. From a statistical standpoint, the conclusion must be drawn that those five independent variables do not explain (or predict) staffing in smaller hospitals. The reasons have been given earlier.

COMPUTATION OF BUILDING AGE

Another interesting problem arises from the fact that most hospitals are not a single building, but are a mix of buildings of various ages. In order to provide an approximation of the overall age of the facility, the WEIGHTED AVERAGE AGE was used. This figure was calculated by multiplying the age of each building by the percentage of square footage that it represented and then adding the weighted ages to get an overall age.

For example, suppose a facility has two buildings, one of 50,000 square feet that is 10 years old and one of 100,000 square feet that is four years old. 33% of the building is 10 years old and 67% of the building is four years old. The weighted average age is calculated below:

\[ (0.33 \times 10) + (0.67 \times 4) / 5.98. \]

By this method, the weighted average age of the building is 5.98 years. As it turned out, the age of the building was not a significant factor in predicting maintenance staffing.

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**CONSTITUTION/ BY-LAWS**

The following are submitted as changes in the N.E.H.E.S Bylaws:

Section 5-14 to read: "The secretary shall have in his possession a current membership listing of all members and be responsible for administrative paperwork concerning new members."

Section 9-3 to read: "The president shall appoint a Membership Committee whose primary function shall be to publicize the activities of the Society and solicit appropriate and qualified members to the Society from the health care industry. Application for membership shall be sent directly to the Membership Chairman with dues money."

Section 10-1 to read: "There shall be an annual meeting held each year during the Fall Seminar as scheduled by the Board of Directors."
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