

ANSI/IEEE Std 602-1986

IEEE Recommended Practice for Electric Systems in Health Care Facilities

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Std 602-1986

An American National Standard

IEEE Recommended Practice for Electric Systems in Health Care Facilities

Sponsor

**Power Systems Engineering Committee
of the
IEEE Industry Applications Society**

Approved March 21, 1985

IEEE Standards Board

Approved July 26, 1985

American National Standards Institute

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Full document details: IEEE 602-1986

First Printing
February 1986

ISBN 0-471-82747-9

Library of Congress Catalog Number 85-081787

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345 East 47th Street, New York, NY 10017 USA

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February 28, 1986 *SH10256*

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Published by
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Dedication

Richard Burgess and John R. Geyer died unexpectedly during the summer of 1984 after completing their chapters. Because of their leadership in developing the White Book, this publication is dedicated to their memory.

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Foreword

(This Foreword is not part of ANSI/IEEE Std 602-1986, IEEE Recommended Practice for Electric Systems in Health Care Facilities.)

The purpose of the IEEE White Book is to promote the use of sound engineering principles in the design and operation of health care facilities. By alerting electrical engineers, designers, and health care operating personnel to the many problems that are encountered in the design and operation of health care facilities, it is hoped that this book will help in the development of concern for the professional aspects of health care facility engineering. While the IEEE White Book provides extensive discussion on each of the major electrical considerations in the design and operation of health care facilities, the IEEE Recommended Practice for Electric Systems in Health Care Facilities is not planned as a complete handbook. It does, however, direct the engineer to texts, periodicals, and references for health care facilities, and in particular, it acts as a guide through the myriad of codes, standards, and recommended practices published by IEEE and other voluntary and governmental bodies.

Initial planning for a recommended practice on electric systems in health care facilities was begun in 1975; however, those first steps were not very productive, and serious consideration was given to abandoning the project or reducing its scope and treating the matter as a single chapter within the IEEE Gray Book on electric systems in commercial buildings. At the very point when the activity appeared to founder, a new chairman accepted the challenge of the project. On October 1, 1979, a reorganized working group, under Hugh O. Nash, Jr, met in Cleveland, Ohio. Nineteen members attended the 1979 meeting. By the time the revitalized activity was fully under way, a total of 53 contributors had been recruited. Included were consultants, design professionals, enforcement officials, electrical and medical manufacturers, and representatives from both the public and private sectors of the health care industry.

Developed within the Power Systems Engineering Committee of the Industrial and Commercial Power Systems Department of the IEEE Industry Applications Society, this Recommended Practice was produced in accordance with consensus procedures of the Institute of Electrical and Electronics Engineers. Under those procedures, accredited by the American National Standards Institute, all concerned parties are assured of an opportunity to participate in development of the document, and resolution of differing viewpoints is subjected to the scrutiny of all participants. The process is necessarily a slow one, but the resulting product can be relied on to meet the needs of professionals throughout the industry and to reflect sound engineering approaches.

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It is the intent of the Power Systems Engineering Committee to maintain this recommended practice so that it continues to remain consistent with the state of the art. Comments and suggestions for future revisions are gratefully solicited. They should be directed to:

Secretary
IEEE Standards Board
345 East 47th Street
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When the IEEE Standards Board approved this standard on March 21, 1985, it had the following membership:

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Electric Systems in Health Care Facilities

First Edition

Electric Systems in Health Care Facilities

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Full document details: IEEE 602-1986

Contents

CHAPTER PAGE

1. Introduction 25
   1.1 General Discussion 25
   1.2 Health Care Facilities 25
   1.3 IEEE Publications 26
      1.3.1 Industry Applications Society 26
      1.3.2 Engineering in Medicine and Biology Society 27
   1.4 Professional Registration 27
   1.5 Codes and Standards 27
      1.5.1 National Electrical Code and Other NFPA Standards 27
      1.5.2 Health Care Codes and Standards 28
      1.5.3 Local, State, and Federal Codes and Regulations 29
      1.5.4 Standards and Recommended Practices 29
   1.6 Handbooks 30
   1.7 Periodicals 31
   1.8 Manufacturers' Data 32
   1.9 Safety 32
      1.9.1 Appliances and Equipment 34
      1.9.2 Operational Considerations 34
   1.10 Maintenance 35
   1.11 Design Considerations 36
      1.11.1 Coordination of Design 36
   1.12 Other Considerations 37

2. Load Requirements and Energy Management 39
   2.1 General Discussion 39
      2.1.1 Loads 39
      2.1.2 Groups of Loads 39
      2.1.3 Load Growth 39
      2.1.4 Energy Utilization 39
   2.2 Loads vs. Facility Type 40
   2.3 Lighting Loads 40
      2.3.1 Loads by Function 40
      2.3.2 Lighting Demand 40
   2.4 Power Loads 41
      2.4.1 Building Equipment 42
      2.4.2 Functional Equipment 43
      2.4.3 Medical Equipment 44
   2.5 Overall Demand Factors 44
   2.6 Energy Management 45
      2.6.1 Energy Economics 50
      2.6.2 Utility Negotiations 51
      2.6.3 Alternative Sources 55
      2.6.4 Design Considerations 56

Documents
Document Sharing Hub

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Full document details: IEEE 602-1986

CHAPTER PAGE
2.6.5 Energy Management Systems 57
2.6.6 Energy Utilization Standards 58
2.7 References 59

3. Electrical Power Distribution Systems 61
3.1 General Discussion 61
3.2 System Planning 62
3.2.1 Consult with the Health Care Facility Administrator(s) and Staff 62
3.2.2 Consult with the Project Architect 63
3.2.3 Determine the Basic Loads and Demand Data 63
3.2.4 Consult with the Local Electric Power Company 63
3.2.5 Consult with the Local Authorities Having Jurisdiction Over New Electrical Construction 64
3.2.6 Summary 65
3.3 Electrical Power Systems 65
3.3.1 Power Sources 65
3.3.2 Distribution Circuits 66
3.4 Voltage Considerations 67
3.4.1 Select System Voltages 67
3.4.2 Nominal Voltage 68
3.4.3 Voltage Variation and Disturbances 68
3.5 Current Considerations 69
3.6 Grounding 70
3.6.1 Equipment Grounding 70
3.6.2 System Grounding 71
3.7 System Protection and Coordination 76
3.7.1 Protection 76
3.7.2 Current Sensing Protectors 77
3.7.3 Ground Fault Protection 78
3.8 Electrical Equipment and Installation 89
3.8.1 Transformers 90
3.8.2 Switchgear, Switchboards and Motor Control Centers 90
3.8.3 Protective Devices 90
3.8.4 Transfer Switches—Automatic and Manual 92
3.8.5 Generators 92
3.8.6 Wire, Cable and Busway 94
3.8.7 Panelboards 95
3.8.8 Isolated Power Supplies 95
3.9 System Arrangements 95
3.9.1 Radial System Arrangement 96
3.9.2 Double Ended System Arrangement 98
3.9.3 Network System Arrangement 100
3.9.4 High-Voltage System Arrangements 102
3.9.5 Existing System Arrangement 102

Documents
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Full document details: IEEE 602-1986

CHAPTER PAGE
3.9.6 Metering Arrangement ... 103
3.10 Standard References ... 103
3.11 Bibliography ... 104

4. Planning for Patient Care ... 105
4.1 General Discussion ... 105
4.2 Wiring Devices ... 105
4.2.1 General ... 105
4.2.2 Hospital-Grade Receptacles—High Abuse ... 106
4.2.3 Hospital-Grade Isolated Ground Receptacle ... 106
4.2.4 Hospital-Grade Safety Receptacles ... 106
4.2.5 Hospital-Grade Ground Fault Circuit Interrupter Receptacles and Ground Fault Circuit Interrupter Circuit Breakers ... 106
4.2.6 Anesthetizing Location Receptacles ... 107
4.2.7 Mobile X-ray Plugs and Receptacles ... 107
4.2.8 High-Abuse Wallplates ... 107
4.2.9 Headwall Units ... 108
4.2.10 Patient Consoles ... 120
4.3 Typical Patient Care Areas ... 120
4.3.1 Patient Rooms ... 121
4.3.2 Coronary Care Areas ... 122
4.3.3 Intensive Care Areas ... 123
4.3.4 Emergency Suites ... 124
4.3.5 Surgical Room ... 124
4.3.6 Pediatrics ... 125
4.3.7 Nurseries ... 125
4.3.8 Psychiatric Care Areas ... 126
4.3.9 Rehabilitation Areas ... 127
4.4 References ... 127

5. Emergency Power Systems ... 129
5.1 General Discussion ... 129
5.1.1 Codes and Standards ... 129
5.1.1.1 Applicability of Codes and Standards ... 130
5.1.1.2 Interpretation ... 130
5.2 Generator Sets ... 130
5.2.1 Location ... 131
5.2.2 Mounting ... 131
5.2.3 Vibration Isolation ... 131
5.2.4 Exhaust System ... 133
5.2.5 Air Supply ... 136
5.2.6 Cooling ... 138
5.2.7 Temperature ... 140
5.2.8 Starting ... 140

Documents
Document Sharing Hub
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Full document details: IEEE 602-1986

CHAPTER PAGE

5.2.9 Governor ... 144
5.2.10 Fuel Supply ... 145
5.2.11 Ratings ... 146
5.2.12 Sizing the Alternator ... 147
5.2.13 Voltage Regulators ... 148
5.2.14 Parallel Operation ... 151
5.2.15 Exciters ... 155
5.2.16 Load Pickup ... 155
5.2.17 Exercising ... 155
5.3 Automatic and Nonautomatic Transfer Switches ... 156
5.3.1 Types of Loads ... 156
5.3.2 Voltage Ratings ... 162
5.3.3 Continuous Current Rating ... 162
5.3.4 Overload and Fault Current Withstand Ratings ... 163
5.3.5 Protective Device Ahead of Transfer Switch ... 163
5.3.6 Source Monitoring ... 163
5.3.7 Time Delays ... 164
5.3.8 Input/Output Control Signals ... 164
5.3.9 Main Switching Mechanism ... 164
5.3.10 Ground Fault Protection Considerations ... 165
5.3.11 System Operation ... 165
5.3.12 Nonautomatic Transfer Switches ... 166
5.3.13 Multiple Transfer Switches vs. One Large Transfer Switch ... 166
5.4 Engine Generator Controls ... 167
5.4.1 General ... 167
5.4.2 Safety Controls ... 168
5.4.3 Automatic Starting ... 168
5.4.4 Engine Generator Control Panel Features ... 170
5.4.5 Remote Annunciator ... 170
5.5 Battery Chargers for Cranking Batteries ... 170
5.5.1 General Description ... 170
5.5.2 Definitions of Terms ... 172
5.5.3 Charger Ratings ... 172
5.5.4 Charger Sizing ... 173
5.5.5 Advantages and Disadvantages of Lead Acid and Nickel Cadmium Cells ... 175
5.5.6 Memory Effect on Nickel Cadmium Batteries ... 176
5.5.7 Typical Performance Features ... 176
5.5.8 Optional Accessory Features ... 177
5.5.9 Installation and Maintenance Data ... 177
5.6 Synchronizing and Paralleling Control Systems for Multigenerator Set Installations ... 178
5.6.1 When to Parallel ... 178

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Full document details: IEEE 602-1986

CHAPTER PAGE

5.6.2 Engine Generator Set Governor Considerations 179
5.6.3 Random Paralleling 179
5.6.4 Dividing the Load 179
5.6.5 Establishing Load Priorities 180
5.6.6 Load Shedding 180
5.6.7 Load Switching Means 180
5.6.8 Typical System Operation 181
5.6.9 Sensing 183
5.6.10 Control Logic Power Sources 186
5.6.11 Instrumentation 187
5.6.12 Generator Power Breaker 188
5.7 Utility Peak Demand Reduction Controls 188
5.7.1 Special Requirements for Health Care Facility Loads 189
5.7.2 Nature of Electrical Load Billing 189
5.7.3 Advantages of Load Demand Control 189
5.7.4 Load Demand Controllers 190
5.7.5 Load Demand Control 190
5.7.6 Determination of Mean Period Between Service Overhauls 191
5.8 Elevator Emergency Power Selector Systems 192
5.8.1 Problems Associated with Regenerative Power 192
5.8.2 Sequence of Elevator Operation on Emergency Power 193
5.8.3 Summary 195
5.9 Bypass/Isolation Switches for Automatic Transfer Switches 195
5.10 Uninterruptible Power Supplies 199
5.11 Maintenance 202
5.12 References 203

6. Electrical Safety and Grounding 205
6.1 General Discussion 205
6.1.1 Purpose 205
6.1.2 Overview 205
6.2 Physiological Parameters 206
6.2.1 Cell Excitability 206
6.2.2 Nerve Reaction to Electrical Stimuli 206
6.2.3 Muscle Reaction to Electrical Stimuli 206
6.2.4 Tissue Reaction to Heat 207
6.2.5 Body/Tissue Resistance 207
6.3 Shock Levels 207
6.3.1 Perception 207
6.3.2 Contraction 207
6.3.3 No-Let-Go 207
6.3.4 Cardiac Fibrillation 207
6.4 Areas of Potentially Increasing Hazards 208

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Full document details: IEEE 602-1986

CHAPTER PAGE

6.4.1 Waiting Rooms, Offices 208
6.4.2 Corridors 208
6.4.3 Psychiatric Patient Room 208
6.4.4 General Medical Care 208
6.4.5 Critical Care Patient Room 208
6.4.6 Recovery Rooms 208
6.4.7 Wet Locations 209
6.4.8 Laboratories 209
6.4.9 Outpatient Care Units with Invasive Procedures 209
6.4.10 Heart Catheterization Rooms 209
6.4.11 Operating Rooms in Which Only Local Anesthetic Agents Are Used 209
6.4.12 Inhalation Anesthetizing Locations 209
6.4.13 Inhalation Anesthetizing Locations Which Become Wet Locations 210
6.4.14 Inhalation Anesthetizing Locations in Which Invasive Thoracic Procedures Are Performed 210
6.4.15 Inhalation Anesthetizing Locations in Which Flammable Anesthetizing Agents Are Used 210
6.5 Fire and Explosion Hazards 210
6.5.1 Flammable Anesthetizing Agents 210
6.5.2 Flammable Cleaning and Preparation Agents 210
6.5.3 Oxygen Enriched Atmosphere 211
6.5.4 Conductive Flooring 211
6.6 Environmental Conditions Relating to Electrical Safety 211
6.6.1 Source of Leakage Currents 211
6.6.2 Limits Set by Standards 213
6.6.3 Protective Measures for Leakage Current 213
6.6.4 Design Factors Affecting Leakage Current 214
6.6.5 Neutral to Ground Short Circuits 214
6.6.6 Line-to-Line Faults 215
6.6.7 Line-to-Ground Faults 215
6.6.8 Transformer Vault Location and Electrical Disturbances 215
6.6.9 Wet Locations 215
6.7 Basic Safety Measures 216
6.7.1 Insulation 216
6.7.2 Grounding 216
6.7.3 Overcurrent Protection 219
6.7.4 Adequacy of Power 219
6.7.5 Continuity of Power 219
6.7.6 Isolated Power 219
6.7.7 Three-Phase Isolated System 223
6.7.8 Limitations 223
6.7.9 Line Isolation Monitor 224

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Full document details: IEEE 602-1986

CHAPTER PAGE

6.7.10 LIM Isolation Monitor Interpretation 225
6.8 Design and Testing of Systems for Safety 226
6.8.1 Identifying Particular User Needs 226
6.8.2 Adjusting Special Design Features for Each Area 226
6.8.3 Distribution Systems 226
6.8.4 Distribution Raceway Systems 226
6.8.5 Distribution System-Grounded and Isolated Power 227
6.8.6 Field Inspection Procedure 227
6.9 References 228

7. Lighting for Health Care Facilities 229
7.1 General Discussion 229
7.2 Lighting Objectives 229
7.3 Design Criteria 231
7.3.1 Luminaire Requirements and Distribution 231
7.3.2 Special Light Distributions from Luminaires 232
7.3.3 Light Sources 232
7.3.4 Room 243
7.3.5 Some Quality Factors in Lighting 245
7.3.6 Illuminance Design Procedure 246
7.4 Functional Design Consideration 248
7.4.1 Nursing Unit (Adult Medical, Surgical and Postpartum Care) 248
7.4.2 Intensive Care Unit 259
7.4.3 Newborn Nurseries Unit 260
7.4.4 Pediatric and Adolescent Unit 261
7.4.5 Psychiatric Nursing Unit 261
7.4.6 Surgical Facilities 262
7.4.7 Obstetrical Facilities 265
7.4.8 Outpatient and Emergency Suite 265
7.4.9 Radiology Suite 269
7.4.10 Laboratory 271
7.4.11 Dialysis 272
7.4.12 Autopsy 273
7.4.13 Pharmacy 273
7.4.14 Long Term Care Facilities 274
7.5 Emergency Lighting 275
7.5.1 Codes 275
7.5.2 Other Considerations 276
7.6 References 276
7.7 Bibliography 278

8. Communication and Signal Systems 279
8.1 System Design Considerations 279
8.1.1 Introduction 279

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Full document details: IEEE 602-1986

CHAPTER PAGE

8.1.2 Programming ... 279
8.1.3 Communication and Signal Facilities ... 280
8.1.4 Communication and Signal Control Centers ... 281
8.1.5 Cable Plant ... 282
8.1.6 Communication and Signal Closets ... 285
8.1.7 Equipment Spaces ... 286
8.1.8 Power Supply ... 286
8.1.9 Computer and Combination Systems ... 288
8.1.10 Future Outlook ... 289
8.2 Telephone Systems ... 289
8.2.1 Introduction ... 289
8.2.2 Design Criteria ... 289
8.2.3 System Types and Selection ... 289
8.2.4 Design Considerations ... 293
8.2.5 Telephone Company Facility Requirements ... 294
8.2.6 EPABX Installations ... 294
8.3 Intercom ... 295
8.3.1 Introduction ... 295
8.3.2 Design Criteria ... 295
8.3.3 System Types and Selection ... 296
8.3.4 Design Considerations ... 297
8.4 Nurse Call Systems ... 298
8.4.1 Introduction ... 298
8.4.2 Design Criteria ... 298
8.4.3 Visual Systems ... 299
8.4.4 Audio-Visual Systems ... 300
8.4.5 Centralized Nurse Call System ... 303
8.4.6 Central Processor Controlled System ... 303
8.4.7 Psychiatric Nurse Call System ... 304
8.4.8 Medical and Dental Offices and Clinics ... 304
8.4.9 Design Considerations ... 305
8.5 Code Blue Systems ... 305
8.5.1 Introduction ... 305
8.5.2 Design Criteria ... 305
8.5.3 System Types and Selection ... 306
8.5.4 Design Considerations ... 306
8.6 Paging and Voice Paging Systems ... 306
8.6.1 Introduction ... 306
8.6.2 Design Criteria ... 306
8.6.3 Voice Paging System Design Criteria ... 307
8.6.4 Design Considerations ... 309
8.7 Radio Paging Systems ... 310
8.7.1 Introduction ... 310
8.7.2 Design Criteria ... 310

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CHAPTER PAGE

8.7.3 Design Considerations 314
8.8 Physician and Staff Register Systems 318
8.8.1 Introduction 318
8.8.2 Design Criteria 318
8.8.3 System Types and Selection 320
8.8.4 Design Considerations 323
8.9 Dictation Systems 324
8.9.1 Introduction 324
8.9.2 Design Criteria 324
8.9.3 System Types and Selection 326
8.9.4 Design Considerations 326
8.10 Patient Physiological Monitoring Systems 327
8.10.1 Introduction 327
8.10.2 Design Criteria 327
8.10.3 Design Considerations 328
8.11 Emergency Medical Service Communications 329
8.11.1 Introduction 329
8.11.2 Design Criteria 329
8.11.3 Design Considerations 329
8.12 Clocks 330
8.12.1 Introduction 330
8.12.2 Design Criteria 330
8.12.3 Design Considerations 331
8.13 Fire Alarm Systems 332
8.13.1 Introduction 332
8.13.2 Design Criteria 332
8.13.3 System Types and Selection 334
8.13.4 Design Considerations 335
8.14 Security Systems 343
8.14.1 Introduction 343
8.14.2 Design Criteria 343
8.14.3 Security Sensors 343
8.14.4 Design Considerations 344
8.15 Facility Monitoring 344
8.15.1 Introduction 344
8.15.2 Medical Gas Alarms 345
8.15.3 Refrigeration Alarms 346
8.15.4 Emergency Generator Monitoring 346
8.15.5 Energy Monitoring and Control Systems 346
8.16 Television Systems 347
8.16.1 Introduction 347
8.16.2 Design Criteria 347
8.16.3 Design Considerations 350
8.17 Sound Reinforcement Systems 353

Documents
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Full document details: IEEE 602-1986

CHAPTER PAGE

8.17.1 Introduction 353
8.17.2 Design Criteria 353
8.17.3 Design Considerations 353
8.18 Data Processing Systems 356
8.18.1 Introduction 356
8.18.2 Design Considerations 357
8.19 Telewriter and Facsimile Systems 357
8.19.1 Introduction 357
8.19.2 Design Criteria 357
8.19.3 Design Considerations 358
8.20 Pneumatic Tube Systems 358
8.20.1 Introduction 358
8.20.2 Design Criteria 358
8.20.3 Design Considerations 358
8.21 Disaster Alarm Systems 358
8.21.1 Introduction 358
8.21.2 Design Criteria 359
8.21.3 Design Considerations 359
8.22 References 359

9. Medical Equipment and Instrumentation 361
9.1 Introduction 361
9.1.1 Need 361
9.1.2 Cost 361
9.1.3 Space Requirements 361
9.1.4 Utilities 361
9.2 Equipment Selection 362
9.2.1 Pre-Purchase Evaluation Form 362
9.2.2 Example of Pre-Purchase Evaluation Form 362
9.3 Equipment and Area Served 366
9.3.1 Patient Care 366
9.3.2 Pediatric and Neonatal 390
9.3.3 Surgery 392
9.3.4 Dialysis 392
9.3.5 Radiology 392
9.3.6 Physical Therapy 405
9.3.7 Neurophysiological Department 408
9.3.8 Pulmonary Function Laboratory (ICU/Neonatal) 410
9.4 References 411

Index 413

FIGURES

Fig 1 Load Profile, Candler General Hospital, 6/29/81-7/31/81 47
Fig 2 Load Profile, Candler General Hospital, 8/1/82-8/31/82 48

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Full document details: IEEE 602-1986

FIGURES PAGE

Fig 3 US Energy Consumption 49
Fig 4 Solidly Interconnected Neutral Conductor Grounded at Service Equipment 74
Fig 5 Transferred Neutral Conductor Grounded at Service Equipment and at Source of Alternate Power Supply 75
Fig 6 Residually Connected Ground Fault Relay 81
Fig 7 Ground Sensor Ground Fault Relay 82
Fig 8 Ground Sensor Ground Fault Relay with Ground Resistor 82
Fig 9 Residually Connected Ground Fault Relay with Shunt Trip Circuit Breaker 83
Fig 10 Ground Sensor Fault Relay 84
Fig 11 Integral Ground Fault Relay 84
Fig 12 Dual Source Electrically Interconnected 85
Fig 13 Ground Fault Current Return Path to Alternate Supply, Neutral Conductor Grounded at Service Equipment Only 86
Fig 14 Ground Fault Scheme for a Normal and Alternate Power Supply Having an Electrical Power Conductor (Neutral) Interconnection Between Supplies 87
Fig 15 Ground Fault Scheme for a Normal and Alternate Power Supply with No Electrical Power Conductor Interconnection Between Supplies 88
Fig 16 Time-Current Characteristics of a Typical Inverse-Time Overcurrent Relay 93
Fig 17 Typical Time-Current Characteristics for Low-Voltage Protection ... 94
Fig 18 Major Components of the Electrical System 97
Fig 19 Time Delay Relay in Transfer Switch of Motor Starter 98
Fig 20 Two Schemes for Distributing Power Through Vertical Risers 99
Fig 21 Normally Open Tie Protector Interlocked With the Main Protectors 100
Fig 22 Network Service 101
Fig 23 Adequately Rated Substation 102
Fig 24 Short Wall Designed for Use in a General Care Patient Area 109
Fig 25 Junction Boxes Located Within the Wall 110
Fig 26 Junction Box Located As Integral Part of Wall Mounting Bracket Above Ceiling 111
Fig 27 Full Single Section General Care Wall 112
Fig 28 Both Vertical and Horizontal Placement of Equipment 113
Fig 29 Unit Using Horizontal Placement of Equipment 114
Fig 30 Neonatal Service Console 116
Fig 31 Free Standing Service Column 117
Fig 32 Free Standing Service Column 119
Fig 33 Steel-Concrete Inertia Spring Mounts 132
Fig 34 Poured Rubber Gasket Between Two Surfaces 132
Fig 35 Back Pressure Nomograph 134

Documents
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Full document details: IEEE 602-1986

FIGURES PAGE

Fig 36 Exhaust Pipe Manifolding Plan View 136
Fig 37 Resistance of Valves and Fittings to Flow of Fluids 141
Fig 38 Fluid Flow in Pipe 142
Fig 39 Hot Well Cooling System 143
Fig 40 Static Exciter-Regulator System 149
Fig 41 Self-Excited Regulated System 150
Fig 42 Separately Excited System 150
Fig 43 Self-Excited Self-Regulated System 151
Fig 44 Interconnection—Single-Phase Sensing 152
Fig 45 Cross-Current Compensation CT Interconnection 154
Fig 46 In-phase Motor Load Transfer 158
Fig 47 Motor Load Disconnect Circuit 159
Fig 48 Neutral Off Position 160
Fig 49 Closed Transition Transfer 160
Fig 50 Automatic Transfer Switch 166
Fig 51 Typical Engine Generator Control Panel 169
Fig 52 Typical Remote Annunciator Panel 171
Fig 53 Battery Recharge Time 174
Fig 54 Dropping Diode Circuit (CEMF) 175
Fig 55 Typical Automatic Paralleling System for Four Engine Generator Sets, Including Nine Automatic Transfer Switches 181
Fig 56 Typical Multiengine Automatic Paralleling System 182
Fig 57 Distorted Wave Shapes 184
Fig 58 AC Sine Waves Representing Differences in Phase Angle, Frequency, Voltage, and Rotation 186
Fig 59 Elevator Emergency Power Transfer System 196
Fig 60 Typical Automatic Transfer and Two-Way Bypass/Isolation Switch 197
Fig 61 Bypass-Isolation Switch in Bypass-to-Normal Position 198
Fig 62 Bypass-Isolation Switch in Test Position 198
Fig 63 Bypass-Isolation Switch with Transfer Switch Removed 198
Fig 64 Typical UPS One Line 200
Fig 65 Grounding Plugs and Twist Lock Receptacles 218
Fig 66 Isolation Panel for the Operating Room 220
Fig 67 Isolation Panel for the Operating Room 221
Fig 68 Surgical Facility Panel 222
Fig 69 Clock Timer 223
Fig 70 5 mA Line Isolation Monitor 224
Fig 71 Patient Monitoring System, Central Station 367
Fig 72 Patient Monitoring System, Bedside Station 368
Fig 73 Patient Monitoring System, Bedside Station 368
Fig 74 Patient Monitoring System—Table or Console, Mounted 369
Fig 75 Patient Monitoring System, Central Station 369

Documents
Document Sharing Hub

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Full document details: IEEE 602-1986

FIGURES PAGE

Fig 76 Instruments in Operating and Intensive Care Areas 370
Fig 77 Instruments in Operating and Intensive Care Areas and Catheterization Labs 370
Fig 78 Catheterization Computer Systems 371
Fig 79 Progressive Care Unit 372
Fig 80 Patient Measurement System 373
Fig 81 Path of Leakage Current with Defective Grounding Wire 374
Fig 82 Grounding for Patient Monitoring Bedside Stations in Intensive Care Units 375
Fig 83 High Frequency Isolation Transformers 376
Fig 84 60 Hz Interference Causes 376
Fig 85 Generation of Differential Voltages from 60 Hz Electromagnetic Signals 377
Fig 86 Electrosurgical Current in a Complete Circuit 377
Fig 87 Floor Plan 379
Fig 88 Conduit Lengths and Sizes 380
Fig 89 Typical Bedside Configuration 381
Fig 90 Wall Mounts 382
Fig 91 Computer System 383
Fig 92 Ceiling Mount Supports for Steel Joist Ceiling Construction 385
Fig 93 Ceiling Mount Supports for Concrete Slab Ceiling Construction 386
Fig 94 Heavy Copper Buss Grounding System 387
Fig 95 Electrocardiogram in Detail 391
Fig 96 Schematic Representation of a Flat Plate Dialyzer 394

TABLES

Table 1 Factors Used in Sizing Distribution System Components 41
Table 2 Factors Used to Establish Major Elements of the Electrical System Serving HVAC Systems 42
Table 3 Service Entrance Peak Demand (Veterans Administration) 45
Table 4 Service Entrance Peak Demand (Hospital Corporation of America) 46
Table 5 Methods of Generating Electricity On-Site 55
Table 6 Medical Gas Manifold Pipe Size 115
Table 7 Load-Bearing Capabilities of Various Materials 133
Table 8 Mean Period Between Service Overhauls 192
Table 9 Table of Leakages Contributed by Wiring 212
Table 10 Table of Leakages Contributed by Equipment 212
Table 11 Maximum Safe Current Leakage Limits 213
Table 12 Recommended Surface Reflectances 243
Table 13 Illuminance Categories and Illuminance Values for Generic Types of Activities in Interiors 247
Table 14 Weighting Factors to Be Considered in Selecting Specific Illuminance within Ranges of Values For Each Category 248

Documents
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Full document details: IEEE 602-1986

TABLES PAGE

Table 15 Illuminance Selections and Lighting Design Considerations 250
Table 16 Color and Color Rendering Characteristics of Common Light Sources 260
Table 17 Clock Sizes 331
Table 18 Recommended Minimum Monitor Sizes 352

Documents
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1. Introduction

1.1 General Discussion. IEEE Std 602-1986, IEEE Recommended Practice for Electric Systems in Health Care Facilities, commonly known as the IEEE White Book, is published by the Institute of Electrical and Electronics Engineers, Inc. (IEEE) to provide a recommended practice for the electrical design for health care facilities. It has been prepared on a voluntary basis by design engineers, health care end users, and electrical and medical manufacturers functioning as the White Book Working Group within the IEEE Commercial Buildings Power Systems Committee.

This recommended practice will probably be of greatest value to the power oriented engineer with limited health care experience. It can also be an aid to all engineers responsible for the electrical design of health care facilities. However, it is not intended as a replacement for the many excellent engineering texts and handbooks commonly in use, nor is it detailed enough to be a design manual. It should be considered a guide and a general reference on electrical design for health care facilities.

1.2 Health Care Facilities. The term "health care facility," as used here, encompasses buildings or parts of buildings that contain hospitals, nursing homes, residential custodial care facilities, clinics, and medical and dental offices. Buildings or parts of buildings within an industrial or commercial complex, used as medical facilities, logically fall within the scope of this book. Thus the specific use of the building in question, rather than the nature of the overall development of which it is a part, determines its electrical design category. Today's health care facilities, because of their increasing size and complexity, have become more and more dependent upon safe, adequate, and reliable electrical systems. Every day new types of sophisticated diagnostic and treatment equipment, utilizing microprocessors or computers, come on the market. Many of these items are sensitive to electrical disturbances and some require a very reliable power source. Invasive medical procedures such as cardiac catheterization have become routine in today's hospital. Such procedures make electrical safety extremely important. Moreover, new medical and surgical procedures are constantly being developed. In addition to the special safety and reliability requirements, health care facilities have unique

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life safety and communication requirements, because patients are generally unable to care for themselves or evacuate themselves in the event of an emergency. For these reasons, perhaps no area of design or construction is changing as fast as health care facilities.

1.3 IEEE Publications. The IEEE publishes several standards similar to the IEEE White Book, prepared by the Industrial Power Systems Department of the IEEE Industry Applications Society.[1]

[1] ANSI/IEEE Std 142-1982, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems.

[2] ANSI/IEEE Std 241-1983, IEEE Recommended Practice for Electric Power Systems in Commercial Buildings.

[3] ANSI/IEEE Std 399-1980, IEEE Recommended Practice for Power System Analysis.

[4] ANSI/IEEE Std 446-1980, IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications.

[5] ANSI/IEEE Std 493-1980, IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems.

[6] IEEE Std 242-1975, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.

The IEEE Recommended Practice for Electric Power Systems in Commercial Buildings, commonly known as the Gray Book, will be of particular importance as a reference book to the hospital designer because of the many similarities between commercial buildings and health care facilities.

1.3.1 Industry Applications Society. The IEEE is divided into 31 groups and societies which specialize in various technical areas of electrical engineering. Each group or society conducts meetings and publishes papers on developments within its specialized area. The Industry Applications Society (IAS) presently encompasses 23 technical committees covering electrical engineering in specific areas (petroleum and chemical industry, cement industry, glass industry, industrial and commercial power systems, and others). Papers of interest to electrical engineers and designers involved in the field covered by the IEEE White Book are, for the most part, contained in the *Transactions* of the IAS.

ANSI/IEEE Std 241-1983 is published by the IEEE on behalf of the Commercial Buildings Committee of the Industrial Power Systems Department of the Industry Applications Society acting through the Gray Book Working Group. Individuals who desire to participate in the activities of the committees, subcommittees, or working groups in the preparation or revision of texts such as this should write or call IEEE Standards Office, 345 East 47 Street, New York, NY 10017.

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[1] These documents can be obtained from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

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1.3.2 Engineering in Medicine and Biology Society. Another IEEE group of interest to the electrical engineer involved in health care facility design is the Engineering in Medicine and Biology Society (EMBS). The EMBS *Transactions* and the EMBS *Magazine* include articles on the physiological effects of electrical shock and other subjects pertinent to electrical safety. Articles dealing with electrical equipment and instrumentation also appear in the EMBS *Transactions*.

1.4 Professional Registration. Most regulatory agencies require that design for public buildings be prepared under the jurisdiction of state-licensed professional architects or engineers. Information on such registration may be obtained from the appropriate state agency or from the local chapter of the National Society of Professional Engineers.

To facilitate obtaining registration in different states under the reciprocity rule, a national professional certificate is issued by the National Bureau of Engineering Registration[2] to engineers who obtained their home-state license by examination. All engineering graduates are encouraged to start on the path to full registration by taking the engineer-in-training examination as soon after graduation as possible. The final written examination in the field of specialization is usually conducted after four years of progressive professional experience.

Clinical Engineering Certification is available through an International Commission. When available, the hospital's clinical engineer should be involved in the electrical design process.

1.5 Codes and Standards

1.5.1 National Electrical Code and Other NFPA Standards. The electrical wiring and design recommendations in the National Electrical Code (NEC), ANSI/NFPA 70-1984, are vitally important guidelines for health care facility engineers. The NEC is revised every three years, and care should be taken to use the edition that is current and adopted by the authority having jurisdiction of enforcement (AHJ) at the time of construction. The NEC is published and available from the National Fire Protection Association (NFPA) and the American National Standards Institute (ANSI).[3] It does not represent a design specification but only identifies minimum requirements for the safe installation and utilization of electricity in the building. It is strongly recommended that the introduction to the NEC, Article 90, covering purpose and scope, be carefully read. The NFPA *Handbook*, of the *National Electrical Code*, sponsored by the NFPA, contains the complete NEC text plus explanations. This book is edited to correspond with each edition of the NEC.

The NFPA publishes the following related documents containing requirements on electrical and medical equipment and systems:

(1) ANSI/NFPA 20-1983, Standard for the Installation of Centrifugal Fire Pumps.

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[2] PO Drawer 1404, Columbia, SC.

[3] ANSI/NFPA publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, or from Publication Sales, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

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(2) ANSI/NFPA 53M-1979, Manual on Fire Hazards in Oxygen-Enriched Atmospheres.

(3) ANSI/NFPA 70B-1983, Recommended Practice for Electrical Equipment Maintenance.

(4) ANSI/NFPA 70E-1983, Standard for Electrical Safety Requirements of Employee Workplaces.

(5) ANSI/NFPA 71-1982, Standard for the Installation, Maintenance, and Use of Central Station Signaling Systems.

(6) ANSI/NFPA 72A-1979, Standard for the Installation, Maintenance, and Use of Local Protective Signaling Systems.

(7) ANSI/NFPA 72B-1979, Standard for the Installation, Maintenance, and Use of Auxiliary Protective Signaling Systems.

(8) ANSI/NFPA 72C-1982, Standard for the Installation, Maintenance, and Use of Remote Station Protective Signaling Systems.

(9) ANSI/NFPA 72D-1979, Standard for the Installation, Maintenance, and Use of Proprietary Protective Signaling Systems.

(10) ANSI/NFPA 72E-1984, Standard on Automatic Fire Detectors.

(11) ANSI/NFPA 75-1981, Standard for the Protection of Electronic Computer/Data Processing Equipment.

(12) ANSI/NFPA 77-1982, Recommended Practice on Static Electricity.

(13) ANSI/NFPA 78-1983, Lightning Protection Code.

(14) ANSI/NFPA 99-1984, Standard for Health Care Facilities.

(15) ANSI/NFPA 101-1985, Code for Safety to Life from Fire in Buildings and Structures.

(16) NFPA 101 HB85, Life Safety Code Handbook.

(17) NFPA FPH1581, Fire Protection Handbook.

ANSI/NFPA 99-1984 replaces NFPA 3M, 56A, 56B, 56C, 56D, 56E, 56G, 56HM, 56K, 76A, 76B, and 76C. NFPA 56A (Inhalation Anesthetics—1978) and 76A (Essential Electrical Systems—1977) are adopted by enforcement authorities for health care facilities and may still be in force in some areas.

The National Electrical Code and other selected NFPA codes are generally adopted by local and state governments for enforcement by electrical and building inspectors and fire marshals.

1.5.2 Health Care Codes and Standards. Additional electrical requirements for health care facilities are included in the Accreditation Manual for Hospitals published by the Joint Commission for the Accreditation of Hospitals (JCAH). Hospitals seeking JCAH accreditation must undergo an inspection semi-annually by JCAH examiners. Accreditation depends on the hospital's conformance with the requirements included in the accreditation manual.

The Department of Health and Human Services publishes a standard entitled, Guidelines for Construction and Equipment of Hospitals and Medical Facilities.[4]

[4] This publication can be obtained from the Superintendent of Documents, US Government Printing Office, Washington, DC 20402.

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This standard includes electrical requirements which must be satisfied by any facility seeking reimbursement from the Federal Government.

Electrical designers working on projects for the Veterans Administration, armed services, and other government agencies must be aware that these agencies generally publish standards for electrical design. These standards or guidelines can be obtained from the appropriate agency.

1.5.3 Local, State, and Federal Codes and Regulations. While most municipalities, counties, and states use the NEC without change, some have their own codes. In some instances the NEC is adopted by local ordinance as part of the building code, with deviations from the NEC listed as addenda. It is important to note that only the code adopted as of a certain date is official, and that governmental bodies may delay adopting the latest code. Federal rulings may require use of the latest NEC regardless of local rulings, so that reference to the enforcing agencies for interpretation on this point may be necessary.

Some city and state codes are almost as extensive as the NEC. It is generally accepted that in the case of conflict, the more stringent or severe interpretation applies. Generally the entity responsible for enforcing the code has the power to interpret it.

Failure to comply with NEC or local code requirements can affect the owner's ability to obtain a certificate of occupancy and may have a negative effect on insurance.

In most states health care construction comes under the jurisdiction of a state health department. In some instances the state will have its own hospital or health care code with specific electrical requirements.

Both state and local authorities may adopt and enforce one of the model building codes written by a regional building officials group. These include the Standard Building Code, the Uniform Building Code, and the National Building Code.

Legislation by the US Federal Government has had the effect of giving standards, such as those of the American National Standards Institute (ANSI), the impact of law. The Occupational Safety and Health Act, administered by the US Department of Labor, permits federal enforcement of codes and standards. The Occupational Safety and Health Administration (OSHA) has adopted the 1971 (or later) NEC for new electrical installations and equipment within the scope of subpart S—Electrical—of OSHA regulations and also for major replacements, modification, or repair installed after March 5, 1972. A few articles and sections of the NEC have been deemed by OSHA to apply retroactively.

A number of states have enacted legislation embodying various energy conservation standards such as ANSI/ASHRAE/IES 90A-1980, Energy Conservation in New Building Design. Such standards establish energy or power budgets that materially affect architectural, mechanical, and electrical designs.

1.5.4 Standards and Recommended Practices. A number of organizations in addition to the NFPA publish documents which affect electrical design. Adherence to these documents can be written into design specifications.

The American National Standards Institute (ANSI) approves the standards of many other organizations. ANSI coordinates the review of proposed standards

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among all interested affiliated societies and organizations to assure a consensus approval. It is in effect a clearinghouse for technical standards of all types.

Underwriters Laboratories, Inc[5] (UL) is a non-profit organization, operating laboratories for investigation with respect to hazards affecting life and property, materials and products, especially electrical appliances and equipment. In so doing, they develop test standards. Equipment which has been tested by UL, and found to conform to their standards, is known as listed or labeled equipment.

The National Electrical Manufacturers Association[6] (NEMA) represents equipment manufacturers. Their publications serve to standardize the manufacture of, and provide testing and operating standards for electrical equipment. The design engineer should be aware of any NEMA standard which might affect the application of any equipment specified by him.

1.6 Handbooks. The following handbooks have, over the years, established reputations in the electrical field. This list is not intended to be all-inclusive, and other excellent references in addition to those listed in 1.3 are available, but are not listed here because of space limitations.

(1) *Applied Protective Relaying* (Westinghouse Electric Corporation, 1976). The application of protective relaying to commercial-utility interconnections, protection of high-voltage motors, transformers, cables, are covered in detail.

(2) *ASHRAE Handbook* (American Society of Heating, Refrigerating, and Air Conditioning Engineers[7] [ASHRAE]). This series of reference books in four volumes, which are periodically updated, details the electrical and mechanical aspects of space conditioning and refrigeration.

(3) BEEMAN, D.L., editor. *Industrial Power Systems Handbook.* New York: McGraw-Hill, 1955. A text on electrical design with emphasis on equipment, including that applicable to commercial buildings.

(4) CROFT, T., CARR, C.C., and WATT, J.H. *American Electricians' Handbook.* 9th edition. New York: McGraw-Hill, 1970. The practical aspects of equipment, construction, and installation are covered.

(5) *Electrical Maintenance Hints* (Westinghouse Electric Corporation, 1974). The preventative maintenance procedures for all types of electrical equipment and the rehabilitation of damaged apparatus are discussed.

(6) *Electrical Transmission and Distribution Reference Book* (Westinghouse Electric Corporation, 1964). All aspects of transmission, distribution, performance, and protection are included in detail.

(7) FINK, D.G. and BEATY, H.W. *Standard Handbook for Electrical Engineers.* 11th ed. New York: McGraw-Hill, 1978. Virtually the entire field of electrical engineering is treated, including equipment and systems design.

(8) *IES Lighting Handbook* (Illuminating Engineering Society[8] [IES]: Application Volume, 1981; Reference Volume, 1984). All aspects of lighting, including see-

[5] 333 Pfingsten Road, Northbrook, IL 60020.
[6] 2101 L Street, NW, Washington, DC 20037.
[7] Publication Sales, 1791 Tullie Circle, NE, Atlanta, GA 30329.
[8] 345 East 47th Street, New York, NY 10017.

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ing, recommended lighting levels, lighting calculations, and design, are included in extensive detail in this comprehensive text.

(9) *Lighting Handbook* (Westinghouse Electric Corporation, 1976). The application of various light sources, fixtures, and ballasts to interior and exterior commercial, industrial, sports, and roadway lighting projects.

(10) McPARTLAND, J. (and the editors of *Electrical Constructions and Maintenance* magazine). *How to Design Electrical Systems*. New York: McGraw-Hill, 1968.

(11) McPARTLAND, J. and NOVAK, W. *Electrical Design Details*. New York: McGraw-Hill, 1960. This reference offers the young engineer insight into the systems approach to electrical design.

(12) SMEATON, R.S., editor. *Motor Applications and Maintenance Handbook*. New York: McGraw-Hill, 1969. Contains extensive, detailed coverage of motor load data and motor characteristics to better coordinate electric motors with machine mechanical characteristics.

(13) SMEATON, R.S., editor. *Switchgear and Control Handbook*. New York: McGraw-Hill, 1977. Concise, reliable guide to important facets of switchgear and control design, safety, application, and maintenance including high- and low-voltage starters, circuit breakers, and fuses.

(14) *Underground Systems Reference Book* (Edison Electric Institute,[9] 1957). The principles of underground construction and the detailed design of vault installations cable systems and related power systems are fully illustrated; cable splicing design parameters are thoroughly covered.

A few of the older texts may not be available for purchase, but are available in most professional offices and libraries.

1.7 Periodicals. *Spectrum*, the basic monthly publication of the IEEE, covers all aspects of electrical and electronic engineering with limited material on health care facilities. This publication, however, does contain references to IEEE books and other publications, technical meetings and conferences, IEEE group, society, and committee activities, abstracts of papers and publications of the IEEE and other organizations and other material essential to the professional advancement of the electrical engineer. The *Transactions* of the Industry Applications Society and the Engineering in Medicine and Biology Society of the IEEE can be useful to health care electrical engineers.

Following are some other well-known periodicals:

(1) *ASHRAE Journal*, American Society of Heating, Refrigerating and Air-Conditioning Engineers.

(2) *Biomedical Electronics*, 455 Mount Arlington, NJ 07856.

(3) *Biomedical Engineering*, 233 Spring Street, New York, NY 10013.

(4) *Consulting Engineer*, Barrington, IL 60010.

(5) *Electrical Construction and Maintenance*, McGraw-Hill, 1221 Avenue of the Americas, New York, NY 10020.

(6) *Electrical Consultant*, One River Road, Cos Cob, CT 06807.

[9] 1111 19th Street, NW, Washington, DC 20036.

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(7) *Fire Journal*, National Fire Protection Association, Batterymarch Park, Quincy, MA 00269.

(8) *Health Care Systems*, 1515 Broadway, New York, NY 10036.

(9) *Hospitals*, American Hospital Publishing, Inc., 211 E. Chicago Avenue, Chicago, IL 60611.

(10) *IAEI News*, International Association of Electrical Inspectors, 802 Busse Highway, Park Ridge, IL 60068.

(11) *Journal of Clinical Engineering*, 1351 Titan Way, Brea, CA 92621.

(12) *Journal of the Operating Room Research Institute*, 100 Campus Road, Totowa, NJ 07512.

(13) *Lighting Design and Application*, Illuminating Engineering Society, 345 East 47th Street, New York, NY 10017.

(14) *Modern Healthcare*, 740 N. Rush St., Chicago, IL 60611.

(15) *Plant Engineering*, 1301 South Grove Avenue, Barrington, IL 60010.

(16) *Professional Engineer*, National Society of Professional Engineers, 2029 K Street Northwest, Washington, DC 20006.

(17) *Specifying Engineer*, Cahners Publishing Company, 5 South Wabash Avenue, Chicago, IL 60603.

1.8 Manufacturers' Data. The electrical industry through its associations and individual manufacturers of electrical equipment issues many technical bulletins, data books, and magazines. While some of this information is difficult to obtain, copies should be made available to each major design unit. The advertising sections of electrical magazines contain excellent material, usually well illustrated and presented in a clear and readable form, concerning the construction and application of equipment. Such literature may be promotional; it may present the advertiser's equipment or methods in a best light and should be carefully evaluated. Manufacturer's catalogs are a valuable source of equipment information. Some manufacturers' complete catalogs are quite extensive covering several volumes. However, these companies may issue condensed catalogs for general use. A few manufacturers publish regularly scheduled magazines containing news of new products and actual applications. Data sheets referring to specific items are almost always available from the sales offices. Some technical files may be kept in microfilm for use either by projection or by printing at larger design offices. Manufacturers' representatives, both sales and technical, can do much to provide complete information on a product.

Manufacturers of specialized hospital electrical equipment often publish design and installation recommendations and technical updates. This is particularly true of isolation panel, standby system, and transfer switch manufacturers.

1.9 Safety. Safety of life and preservation of property are two of the most important factors in the design of the electrical system. This is especially true in health care facilities because of public occupancy, thoroughfare, high occupancy density and patients—some of them critically ill or injured. In many health care facilities the systems operating staff has limited technical capabilities and may not have any specific electrical training.

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Various codes provide rules and regulations as minimum safeguards of life and property. The electrical design engineer often needs to provide greater safeguards than outlined in the codes according to his best judgment, while also giving consideration to utilization and economics.

Personnel safety may be divided into five categories

(1) Safety for maintenance and operating personnel.
(2) Safety for the general public.
(3) Safety for general patients.
(4) Safety for critical patients or patients subject to invasive procedures.
(5) Safety for anesthetized patients.

Safety for maintenance and operating personnel is achieved through proper design and selection of equipment with regard to enclosures, key-interlocking, circuit breaker and fuse interrupting capacity, the use of high-speed fault-detection and circuit-opening devices, clearances from structural members, grounding methods, disconnecting means and identification of equipment.

Safety for the general public requires that all circuitmaking and breaking equipment as well as other electrical apparatus be isolated from casual contact. This is achieved by using locked rooms and enclosures, proper grounding, limiting of fault levels, installation of barriers and other isolation, proper clearances, adequate insulation, and other similar provisions outlined in this standard.

Safety for general patients requires all of the design features used for protecting the general public as well as special provisions to minimize potential difference between any two conducting surfaces likely to come in contact with the patient directly or indirectly. A green ground conductor is required for all patient care areas to keep potential below 500 mV under normal conditions.

Potential differences in critical care areas must be kept below 40 mV under normal conditions. However, the designer must be aware that even with #10 ground conductors connected to form an equipotential grounding system, potential differences higher than 40 mV can be generated during fault conditions. Equipotential grounding or other special protective systems such as isolation transformers are used in critical care areas to protect catheterized patients from electric shock through an exposed catheter.

Patients under anesthesia are treated as critical patients. Where flammable anesthesia is used, isolation transformers and a properly grounded conductive floor shall be provided. All wiring in the hazardous area must be installed as required for Class 1 Division 1 locations.

The National Electrical Safety Code (NESC), ANSI C2, 1984 edition, is available from the IEEE and ANSI. A cloth-bound hardcover edition may be obtained from John Wiley & Sons Inc, New York. It covers outdoor distribution systems, supply and communications systems, overhead lines, high-voltage systems, and other items related to the supply of building power.

Circuit protection is a fundamental safety requirement of all electrical systems. Adequate interrupting capacities are required in services, feeders, and branch circuits. Selective, automatic isolation of faulted circuits represents good engineering. Tripping schemes for the emergency system must be selective, so that faults on

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adjacent branches or systems or faults on the emergency system itself do not disrupt service to unaffected emergency system circuits—especially if interruption of these circuits can jeopardize the lives or safety of patients. Physical protection of wiring by means of approved raceways under all probable conditions of exposure to electrical, chemical, and mechanical damage is necessary.

Circuits on the emergency system shall be installed in metallic raceway. Circuits to patient care areas shall be installed with a green ground conductor and should be installed in metallic raceway to insure physical protection and to provide redundant grounding. Such raceways should be of sufficient size for future expansion. Additional raceways and spare conductors for future use may be installed within allowable financial constraints. If the raceways are properly constructed and bonded, they can minimize power interruptions. The design engineer should locate equipment where suitable ambient temperatures exist and ventilation is available. The operation of fault-detection and circuit-interruption devices under conditions of abnormal voltage and frequency should be assured.

1.9.1 Appliances and Equipment. Improperly applied or inferior materials can cause electrical failures. The use of appliances and equipment listed by the Underwriters Laboratories, Inc, or other approved laboratories is recommended. The Association of Home Appliance Manufacturers[10] (AHAM) and the Air-Conditioning and Refrigeration Institute[11] (ARI) specify the manufacture, testing, and application of many common appliances and equipment.

High-voltage equipment is manufactured in accordance with NEMA, ANSI, and IEEE standards, and the engineer should make sure that the equipment he specifies conforms to these standards. Properly prepared specifications can prevent the purchase of inferior or unsuitable equipment. The lowest initial purchase price may not result in the lowest cost after taking into consideration operating, maintenance, and owning costs. Value engineering is an organized approach to identification of unnecessary costs utilizing such methods as life cycles, cost analyses, and related techniques.

1.9.2 Operational Considerations. When the design engineer lays out equipment rooms and locates electrical devices, he cannot always avoid having some areas accessible to unqualified persons. Dead-front construction should be utilized whenever practical. Where dead-front construction is not available, all exposed electrical equipment should be placed behind locked doors or gates. This will result in a reduction in electrical failures caused by human error, as well as improved safety.

A serious cause of failure, which is attributable to human error, is unintentional grounding or phase-to-phase short circuiting of equipment which is being worked upon. By careful design such as proper spacing and barriers, and by enforcement of published work-safety rules, the engineer can minimize unintentional grounding and phase-to-phase, and ground faults in the distribution equipment. High-quality workmanship is an important factor in the prevention of

[10] 20 North Wacker Drive, Chicago, IL 60606.
[11] 1501 Wilson Boulevard, Arlington, VA 22209.

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electrical failures. Therefore, the design should incorporate features that are conducive to good workmanship.

Selective coordination of overcurrent devices is important in health care facilities, especially for critical care areas of hospitals. The system must be studied for both high and low level faults. It is also important to consider the different levels of available short circuit current available from utility and standby sources.

Ground fault protection schemes on large service mains on grounded 480 volt systems will help to minimize damage from arcing ground faults. Arcing ground faults or "burndowns" can cause total destruction of electrical equipment, jeopardizing patient safety by fire and loss of electrical service. By providing one or more additional steps of ground fault protection downstream, designers can insure that otherwise harmless ground faults (such as in the powerhouse or kitchen) will not take out the hospital main or patient care areas of the hospital. Ground fault systems should be tested for selective tripping to insure proper and safe operation.

1.10 Maintenance. Maintenance is essential to proper operation. The installation should be so designed that building personnel can perform most of the maintenance with a minimum need for specialized services. Design details should provide proper space and accessibility so that equipment can be maintained without difficulty and excessive cost.

The engineer should consider the effects of a failure in the system supplying the building. Generally, the external systems are operated and maintained by the electrical utility, though at times they are a part of the health care facility distribution system.

In health care facilities where continuity of service is essential, suitable emergency and standby equipment should be provided. Such equipment is needed to maintain minimum lighting requirements for passageways, stairways, and to supply power to critical patient care areas and essential loads. These systems are usually installed within the building, and they include automatic or manual equipment for transferring loads on loss of normal supply power or for putting battery- or generator-fed equipment into service.

Although applicable codes determine the need for standby or emergency generating systems in health care facilities, they are generally required in any facility that keeps acutely ill patients overnight, performs invasive procedures, administers anesthesia, or otherwise treats patients unable to care for themselves during an emergency. High rise health care facilities regardless of type should have on site emergency or standby generators.

Electrical engineers should consider the installation of bypass/isolation switches in conjunction with automatic transfer switches to permit maintenance on a deenergized transfer switch without jeopardizing patient safety. The isolation/bypass switch permits removal of the transfer switch from the circuit while providing for manual transfer to the normal or emergency source.

Even with isolation/bypass switches, it is possible for a load side circuit breaker to fail killing power to all or part of the critical branch. For this reason it is often wise to provide some normal circuits in critical patient care areas.

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1.11 Design Considerations. Electrical equipment usually occupies a relatively small percentage of the total building space, and in design it may be easier to relocate electrical service areas than mechanical areas or structural elements. Allocation of space for electrical areas is often given secondary consideration by architectural and related specialties. In the competing search for space, the electrical engineer is responsible for fulfilling the requirements for a proper electrical installation while at the same time recognizing the flexibility of electrical systems in terms of layout and placement.

Today, architectural considerations and appearances are of paramount importance in the design of a health care facility. Aesthetic considerations may play an important role in the selection of equipment, especially lighting equipment. Provided that the dictates of good practice, code requirements, and environmental considerations are not violated, the electrical engineer may have to compromise in his design to accommodate the desires of other members of the design team.

1.11.1 Coordination of Design. The electrical engineer should work closely with professional associates, such as the architect, the mechanical engineer, the structural engineer, and the civil engineer. He is also concerned with the building owner or operator who, as clients, may take an active interest in the design. More often the electrical engineer will work directly with the coordinator of overall design activities, usually the architect. He should cooperate with the safety engineer, fire protection engineer, the environmental engineer, and a host of other concerned people, such as interior designers, all of whom have a say in the ultimate design.

The electrical designer should become familiar with local rules and know the authorities having jurisdiction over the design and construction. The designer should always contact the authorities having jurisdiction and all applicable utilities before beginning design. Local contractors are usually familiar with local ordinances and union work rules and can be of great help in avoiding pitfalls. Union work practices may, for reasons of safety or other considerations, discourage the use of certain materials and techniques.

In performing electrical design, it is essential, at the outset, to prepare a checklist of all the design stages that have to be considered. Major items include temporary power, access to the site, and review by others. It is important to note that certain electrical work may appear in nonelectrical sections of the specifications. For example, furnishing and connecting of electric motors and controls may be covered in the mechanical section of the specifications. Another notable example would be elevators which are usually specified by the architect. The electrical engineer should make it his business to see that the proper starter, fireman's recall system, and emergency sequencing of elevators are specified.

Electrical engineers working on health care projects should have a working knowledge of medical gas systems because medical gas outlets often share consoles and headwalls he specifies. He should also be familiar with medical gas alarm systems. For administrative control purposes, the electrical work may be divided into a number of contracts, some of which may be under the control of a general contractor and some of which may be awarded to electrical contractors.

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Among items with which the designer will be concerned are preliminary cost estimates, final cost estimates, plans or drawings, specifications (which are the written presentation of the work), materials, manuals, factory inspections, laboratory tests, and temporary power. He may well be involved in providing information on how electrical considerations affect financial justification of the project in terms of owning and operating costs, amortization, return on investment, and related items.

1.12 Other Considerations. Those involved in the design of health care facilities should understand the process by which drawings are issued for bidding and construction. The designer should also have some knowledge of shop drawing review, estimating, and contract administration. For more information see the Introduction (Chapter 1) to the IEEE Gray Book.

Design and construction of health care facilities are a team process involving engineers, architects, construction managers, general contractors, subcontractors and equipment vendors. In recent years the contractors and construction managers have become increasingly involved in the design process. In order to successfully complete a health care project, it is important to involve contractors who have a successful track record in health care construction. The larger and more complex the project the more important it is to have contractors who are skilled and experienced in the specialized construction techniques required for medical facilities.

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2. Load Requirements and Energy Management

2.1 General Discussion. As with other building types, the determination of loads to be served by the electrical system is fundamental to health care facility design. Equally important is the economic application of materials, labor, and electrical devices to serve identified loads. As a goal, the completed facility should serve the initial loads, provide a margin for incremental growth, and foster the efficient use of energy.

2.1.1 Loads. One of the purposes of this chapter is to aid the designer in estimating loads usually found in health care facilities and to show the range of power typically required by these loads.

2.1.2 Groups of Loads. The cumulative effect of groups of individual loads is one of the determinants of distribution system design. This chapter will provide data from operating health care facilities that will be useful in projecting total load demand. Similarly, a profile for one type of facility will be presented. The reader is cautioned that such data should be viewed within the narrow scope in which it is presented. That is, the data is indicative of a specific building at a specific point in time and cannot be extrapolated necessarily into a typical profile.

2.1.3 Load Growth. Patterns of health care have changed rapidly in recent years, and as the biological sciences continue to advance, altering patterns may be expected in the future. Such changes impose on health care facilities the need to adapt to changing demands of many kinds. The designer of electrical systems should plan for inevitable change and should anticipate incremental growth of loads during the useful life of the facility. In fact, the designer's recognition of the dynamic nature of health care facilities may result in extended useful life. Obviously, the type of health care facility affects the level of change that may be anticipated. Teaching hospitals are more prone to change than community general hospitals, and the latter more so than custodial care facilities.

2.1.4 Energy Utilization. Electrical system design affects the energy required to operate a facility over its useful life. This consideration should be balanced with the loads to be served as the design is created. Another purpose of this chapter is to present data that will help reduce the unknowns faced by the

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designer, resulting in a more energy efficient facility. Additionally, techniques of energy management will be discussed.

2.2 Loads vs. Facility Type. There are many types of health care facilities, some of which are identified in the introduction. Load density for the total building will vary as the type varies.

Teaching and general hospitals may be expected to offer the broadest spectrum of load types and to yield the highest concentration of load per gross square foot. Conversely, minimal care and custodial care facilities will produce generally low concentrations of load.

Outpatient screening clinics and physicians' offices will be similar to commercial office buildings, except that screening clinics sometimes will include extensive laboratory and radiology facilities.

Psychiatric hospitals, nursing homes, minimal care and custodial care facilities share a common bond since large portions of each will be devoted to patient accommodations. While the similarity will stop there in most cases, the load density (watts per gross square foot) will be influenced significantly by their residential character.

Load density is related to other variables in addition to facility type. As an example, choice of fuel for heating and air conditioning will exert considerable influence on loads.

2.3 Lighting Loads. Lighting for health care facilities is presented in Chapter 7. Loads imposed by the lighting systems will be a function of several variables, among which are:

(1) Tasks to be performed
(2) Quality and quantity of illumination required
(3) Choice of lighting sources.

Lighting design for some areas will be similar to that for other commercial buildings. Other spaces will require the application of specialized lighting techniques. Among the latter are patient rooms, intensive care units, nurseries, and surgical and obstetrical suites.

In all cases, task lighting techniques should be applied, in the interest of energy management and of optimum distribution system capacity.

2.3.1 Loads by Function. For initial calculations, lighting connected loads may be estimated relying on the designer's previous experience or they may be estimated using the IES lighting power budget technique. Readers should refer to the references for this chapter and to the body of Chapter 7 for more on this subject.

2.3.2 Lighting Demand. As with other types of loads, demand factors may be applied to lighting connected load when determining distribution system component capacity. The appropriate factor will depend upon some or all of the following:

(1) Function performed in the area served
(2) Means of lighting control, that is, switching, dimming
(3) Hours of operation for the area served.

As an upper limit, the continuous load supplied by a lighting branch circuit should not exceed 80% of the branch circuit rating. For good design practice, the

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continuous load supplied should not exceed 70% of the branch circuit rating.

ANSI/NFPA 70-1984 [2][12] permits the use of lighting demand factors in calculating lighting load on feeders. Refer to Table 220-11. However, designers should develop their own factors based on the characteristics of a specific project, consistent with restraints imposed by code authorities.

The factors shown in Table 1 may be used in sizing the distribution system components shown and should result in a conservative design. The factors should be applied to connected lighting load in the first step, and then, to the product resulting from previous steps as the designer proceeds through the system.

2.4 Power Loads. Power loads may be divided into broad categories:

(1) Building equipment
  (a) Heating, ventilating, air conditioning
  (b) Transportation (elevators, escalators, trolleys)
  (c) Auxiliary pumps (fire, sump, clinical air and vacuum, pneumatic tube)

(2) Functional equipment
  (a) Kitchen
  (b) Data processing
  (c) Communication systems
  (d) Office machines and copy equipment

(3) Medical equipment
  (a) X-ray
  (b) Radiation therapy
  (c) Laboratory
  (d) Surgery
  (e) Intensive care, recovery, emergency
  (f) Physical and occupational therapy
  (g) Inhalation therapy
  (h) Pharmacy
  (i) Materials management
  (j) Medical records.

NOTE: Major loads occur in the first two categories, and these loads are similar to those in other types of commercial buildings. The third category is unique to health care.

Table 1
Factors Used in Sizing Distribution System Components

Distribution System Component	Lighting Demand Factor
Lighting panelboard buss and main overcurrent device	1.0
Lighting panelboard feeder and feeder overcurrent device	1.0
Distribution panelboard buss and main overcurrent device	
First 50 000 W or less	0.5
All over 50 000 W	0.4
Remaining components	0.4

[12] The numbers in brackets correspond to those in the references at the end of this chapter.

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2.4.1 Building Equipment. The types of heating, ventilating, and air conditioning systems chosen for a specific building will have the greatest single effect on electrical load. First, the choice of fuel will be critical. If natural gas, fuel oil, or coal is chosen, electrical loads will be lower than would be the case if electricity were chosen. Second, the choice of refrigeration cycle will have considerable impact. If absorption chillers are chosen, electrical loads will be lower than those imposed by electric centrifugal or reciprocating chillers. Early discussions between mechanical and electrical designers will be advantageous in planning the electrical distribution system.

For initial estimates, before actual loads are known, the factors shown in Table 2 may be used to establish the major elements of the electrical system serving HVAC systems.

Elevators usually are large loads, but since only a few are required in most health care facilities, elevators do not represent a large portion of total load. For preliminary design of the distribution system in buildings of up to twelve stories, assuming vertical speeds up to 450 ft/min, 4500 lb capacity, the following loads may be used:

Electric traction elevators, each	35–50 hp
Hydraulic elevators, each	40–75 hp

Hydraulic elevators ordinarily will not be employed in buildings higher than seven stories and speeds usually will be limited to 150 ft/min. However, capacities

Table 2
Factors Used to Establish Major Elements of the Electrical System Serving HVAC Systems

Item	Unit
Refrigeration Machines:	kVA/Ton of Chiller Capacity
Absorption	
Centrifugal	1.00
Reciprocating	
Auxiliary Pumps & Fans:	
Chilled Water Pumps	0.08
Condenser Water Pumps	
Absorption	
Centrifugal/Reciprocating	0.07
Cooling Tower Fans	
Absorption	
Centrifugal/Reciprocating	0.07
Boilers:	kVA/Boiler Horsepower
Natural Gas/Fuel Oil	0.07
Coal	
Boiler Auxiliary Pumps:	kVA/Boiler Horsepower
Deaerator	0.10
Auxiliary Equipment:	kVA/Bed
Clinical Vacuum Pumps	0.18
Clinical Air Compressors	0.10

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may be higher than 4500 lb. Actual loads should be obtained from the elevator vendor once vertical transportation requirements have been defined sufficiently to permit calculation.

Escalators are not used frequently in health care facilities but may be employed in a few buildings. For initial estimates, escalator load will approximate 25 hp for each landing served above the first.

Horizontal and vertical transportation systems for food, supplies, and materials using automated trolleys or carts are found in a few large health care facilities. Pneumatic tube systems are more common and may be employed as the sole means of transport for small supplies and paper records or as one component in a materials handling system. Automated trolleys or carts impose relatively small loads (less than 10 hp) at numerous locations but will usually be combined with dedicated elevators whose loads will be similar to a service elevator. Pneumatic tube systems are powered by vacuum pumps or exhausters located in a few central locations. Motor drives will vary depending on the extent of the system but are under 10 hp (many, less than 3 hp).

2.4.2 Functional Equipment. Equipment of this type usually consists of numerous small loads except that used in kitchens and except for some office copiers. The effect on the electrical system is to require panelboard space and multiple branch circuits but low load density.

The choice of fuel in the kitchen is the major determinant. If natural gas is the primary fuel, electrical loads will be lower on a watts per square foot basis than where electricity is the primary fuel. Preliminary planning should address this question early. For estimating purposes, the following factors may be used. In calculating kitchen floor area include cooking and preparation, dishwashing, storage, walk-in refrigerator/freezer, food serving lines, tray assembly and offices.

Primary Fuel	Watts/Square Foot
Natural Gas	25
Electricity	125

Computer equipment is employed in several areas of the typical hospital. As a minimum, stand-alone systems for patient and general accounting and for laboratory analyses may be anticipated. However, it is common to find these integrated into hospital-wide management information systems today. Such systems use multiple input stations throughout the hospital, all intended to produce a unified patient bill at the time of patient discharge plus inventory control, third party billing, and portions of the patient's medical record.

As in other types of facilities, computer power requirements are usually moderate at the central processor location and low at distributed input stations. For most installations found in hospitals, the total load at the central location will not exceed 45 kVA. Occasionally, large systems or multiple systems housed together may require up to 75 kVA.

At CRT or teletype input stations, power demand will not exceed 1 kVA.

While the quantity of power is important, the quality and reliability of the voltage supply are equally important. Use of isolating transformers is common, often

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including electrostatic shields. While there are exceptions, use of uninterruptible power supplies is not common. However, service as direct from the source as possible would be desirable.

Power demand from communication systems, as individual loads and as a whole, is low. Individual loads will not exceed 2 kVA usually, with most less than 1.5 kVA.

As in other commercial structures, there will be a large quantity of office equipment (typewriters, word processors, copiers) but power required will be low, on the order of 0.3 to 1.2 kVA per item. The exception will be large copy machines. These may be estimated at 3 to 6 kVA each.

2.4.3 Medical Equipment. Types of medical equipment employed in the several departments of health care facilities are discussed in Chapter 9.

Power distribution systems serving multiple X-ray machine installations require special attention. Designers should always be guided by the specific data furnished by vendors supplying equipment for the specific facility. However, an excellent planning guide is available as a NEMA standard (NEMA XR9-1984 [4]) and should be consulted.

Quality of voltage supplied is important to X-ray installations. Again, service as direct as possible from the source is desirable. Minimum transient disturbance and voltage drop are essential.

While momentary demand of X-ray installations will figure prominently in feeder and distribution equipment sizing, it need not be considered in calculating overall power demand imposed on the source, provided it is a part of a moderate size system. If the system requires 750 kVA or more, the momentary nature of X-ray operation will not add measurably to the overall demand. For small systems and for additions to existing facilities where service equipment is near capacity, some provision for X-ray demand may be advisable.

Clinical laboratories in hospitals require numerous branch circuits to serve the multitude of electrical devices but load density is usually low and individual equipment loads are low, most under 1 kVA. A few pieces of equipment in laboratories today perform multiple specialized tests. The loads for these will range between 3 and 8 kVA each. These same items often are sensitive to transient conditions on the power system and may require locally applied transient suppressors.

2.5 Overall Demand Factors. A tabulation of actual service entrance demand per gross square foot is presented in Tables 3 and 4 for a group of health care facilities. Data used in preparation of these tables was obtained from the Veteran's Administration and Hospital Corporation of America. Refer to footnotes accompanying the tables for the criteria on which these tables are based.

The tables show the type of facility, the gross floor area and number of beds for each, the geographic location and the major fuel type employed for HVAC systems in that facility. The derived factors may be used to estimate the anticipated demand for other facilities similar in size, location, and type of fuel. They also may be used to make initial estimates of service entrance capacity, switchgear

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size and space required for service entrance equipment. It is important to recognize, however, that they will be useful principally in the schematic design phase. As design proceeds through the preliminary and working drawing phases, these initial estimates should be modified by the actual conditions prevalent in the project.

Figures 1 and 2 present operating load data for a large general medical and surgical hospital located in the southeastern United States. It should be useful in visualizing changes in demand over time for a typical operating hospital. Candler General Hospital is a 305 bed facility, 402 000 gross ft^2, situated in Savannah, Georgia. The principal fuel employed for heating is natural gas with fuel oil standby. The chillers are centrifugal. Data for the charts was obtained by operating personnel during the cooling season, the peak period in this location.

2.6 Energy Management. To gain a better perspective of the impact of energy management on the nation's plan to meet future energy goals, an overall view of past, current and projected energy usage is necessary. Government and independent researchers have developed energy consumption projections to the year 2000 based on historical data on the total domestic energy usage over the past 81 years. Figure 3 is a graphic representation of usage from 1900 to 1981. Energy used in "quads" is plotted against years. A quad is 1 quadrillion Btu's (2.93×10^{11} kWh) or more conveniently the approximate amount of energy used by a city of 1 million people every three years. The distribution of usage by industrial, residential and commercial, and transportation is respectively three-eighths, three-eighths, and one-quarter of the total: 74 quads. An extrapolation of the historical data and a reasonable projection by the National Academy of Sciences to the year 2000 indicates consumption could be 175 quads. By incorporating the best

Table 3
Service Entrance Peak Demand (Veterans Administration)

Hospital	Floor Area Square Feet	Beds*	Degree Days† Cooling	Degree Days† Heating	Principal‡ Fuel-HVAC	Watts Per Sq ft§ Maximum	Watts Per Sq ft§ Average
V.A. Hospital #1	821 000	922	234	3536	NG/FO	4.5	3.5
V.A. Hospital #2	334 000	500	863	5713	NG/FO	5.2	3.9
V.A. Hospital #3	645 995	670	3488	1488	NG/FO	3.8	2.8
V.A. Hospital #4	681 000	600	1016	654	NG/FO	6.1	4.0
V.A. Hospital #5	503 500	697	3495	841	NG/FO	7.2	5.5
V.A. Hospital #6	800 000	1050	600	7400	NG/FO	5.9	4.2

* Total beds shown. Beds actually occupied could affect values shown for watts per square foot.

† Degree Days: Normals, Base 65 °F, based on 1941-70 period. From *Local Climatological Data* Series, 1974, NOAA.

‡ NG/FO = Natural Gas/Fuel Oil; E = Electricity. Principal fuel is defined as that used for heating. In all cases, electricity was the fuel used for refrigeration.

§ Watts per square foot based on measured values at service entrance during metering periods ranging from 9 to 17 days, during cooling season in all instances, 1981.

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Table 4
Service Entrance Peak Demand (Hospital Corporation of America)

Hospital and Location	Floor Area Square Feet	Beds*	Degree Days† Cooling	Degree Days† Heating	Principal‡ Fuel-HVAC	Watts Per Sq ft§ Maximum
#1 — East	273 000	458	1353	3939	NG/FO	6.8
#2 — Southeast	278 000	250	2294	2240	NG/FO	6.3
#3 — Central	123 000	157			NG/FO	7.5
#4 — Central	36 365	62	2029	3227‖	E	13.7
#5 — Central	318 000	300	1107	4306	NG/FO	4.6
#6 — Southeast	182 000	225	3786	299‖	NG/FO	5.3
#7 — East	283 523	320	1030	4307	NG/FO	6.8
#8 — Southwest	135 396	150	2250	2621‖	NG/FO	6.6
#9 — West	190 000	97	927	5983	NG/FO	2.8
#10 — Southeast	161 000	170	3226	733‖	NG/FO	6.3
#11 — Southeast	157 639	214	2078	2146	NG/FO	7.3
#12 — Southeast	162 187	222	2143	2378‖	NG/FO	4.3
#13 — East	109 617	146	1030	4307‖	NG/FO	5.7
#14 — East	76 000	153	1030	4307‖	E	8.8
#15 — Southeast	135 150	190	1995	2547‖	NG/FO	5.9
#16 — Southwest	75 769	131	2587	2382‖	NG/FO	7.4
#17 — Central	75 769	128	1636	3505‖	NG/FO	6.3
#18 — Northwest	129 000	150	714	5833‖	NG/FO	4.4
#19 — Central	54 938	108	1694	3696‖	E	13.3
#20 — West	144 000	160	2814	1752	NG/FO	4.5
#21 — Southeast	149 000	123	2078	2146‖	NG/FO	4.5
#22 — Central	89 000	128	2029	3227‖	E	8.4
#23 — Central	128 500	150	1197	4729‖	NG/FO	6.2
#24 — West	135 169	170	927	5983‖	NG/FO	4.7
#25 — Southeast	80 000	124	1722	2975‖	NG/FO	6.2
#26 — Southeast	83 117	126	3226	733‖	NG/FO	8.5
#27 — Central	51 000	97	1569	3478	E	8.8
#28 — Southeast	66 528	120	2929	902‖	E	9.7
#29 — East	112 000	140	1394	3514	NG/FO	4.3
#30 — Central	202 000	223	1636	3505	NG/FO	4.8
#31 — Southeast	56 000	51	3786	299‖	NG/FO	7.4
#32 — West	47 434	50	927	5983‖	NG/E	7.0
#33 — Central	23 835	32	1694	3696‖	E	10.8
#34 — Southeast	105 000	95	2706	1465‖	NG/FO	8.3
#35 — West	48 575	60	3042	108‖	NG/E	7.7
#36 — Southwest	133 000	185	2587	2382‖	NG/FO	6.3
#37 — Central	42 879	66	1694	3696‖	E	15.7

* Total beds shown. Beds actually occupied could affect values shown for watts per square foot.

† Degree Days: Normals, Base 65 °F, based on 1941-70 period. From *Local Climatological Data* Series, 1974, NOAA.

‡ NG/FO = Natural Gas/Fuel Oil; E = Electricity. Principal fuel is defined as that used for heating. In all cases, electricity was the fuel used for refrigeration.

§ Watts per square foot based on measured values by utility company meter at service entrance, 1977.

‖ Data shown for nearest recorded location.

(Each facility was self-contained, in that refrigeration and air conditioning equipment loads are included in power demands shown.)

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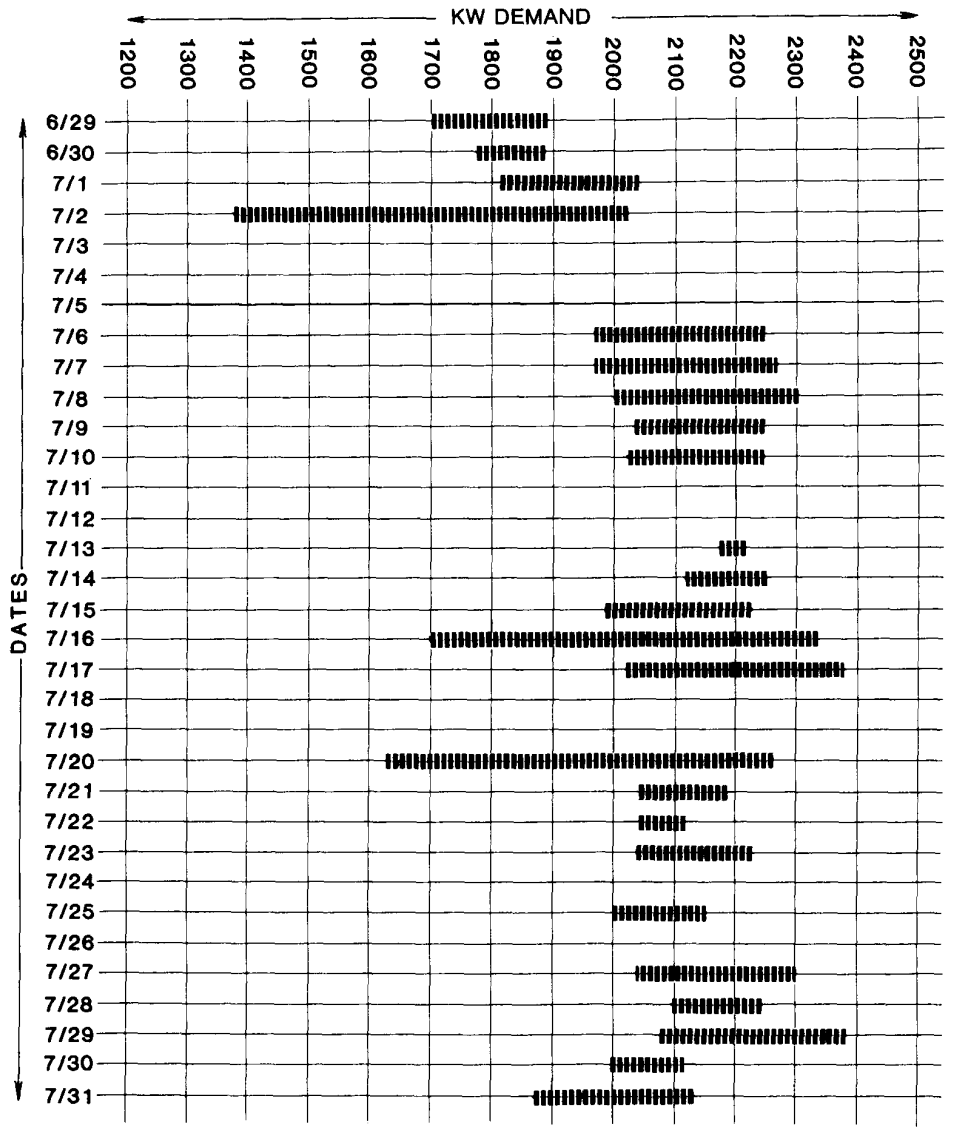


Fig 1
Load Profile
Candler General Hospital
6/29/81-7/31/81
kW Demand

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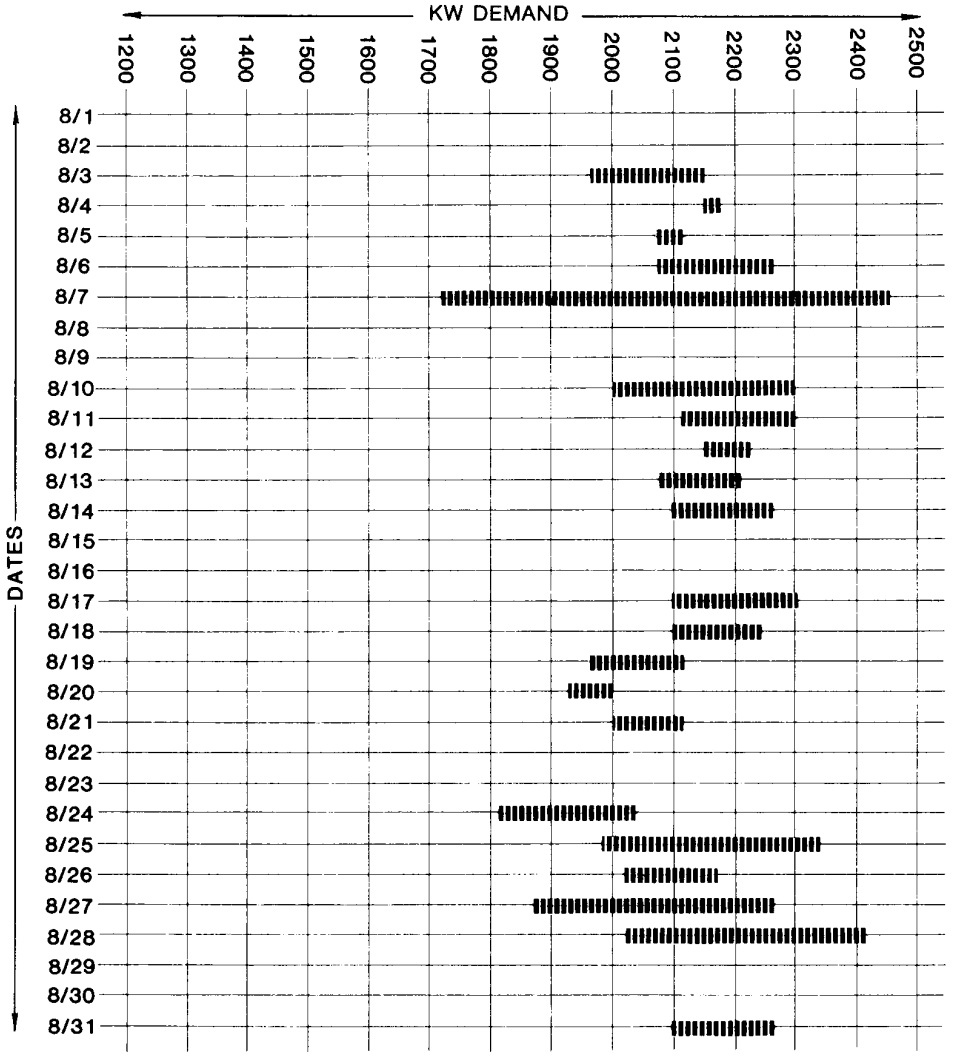


Fig 2
Load Profile
Candler General Hospital
8/1/82-8/31/82
kW Demand

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