In planning the development of this model, the first and second divisions of a work breakdown structure (WBS) were formulated to describe frequently occurring gaps that must be bridged before automation is fully integrated throughout the plant. There were seven major divisions. Next, the standards that are useful when integrating automated equipment in a computerized plant were identified. Over 400 organizations within the United States prepare standards, but it is a select few (ASTM, CCITT, EIA, IEEE, and ISA) that write most of the standards related to industrial automation. Only those standards concerned with integration of the automated equipment (instead of the equipment itself) were considered. Standards inapplicable to the integration process were not considered. The standards thus identified as being useful when integrating automated equipment were then placed into one or more of the WBS divisions. The end result was this Appendix, an Integrated Standards Structure for Automated Manufacturing. The listing of the standards in the chart is not intended to be complete, but it is a necessary beginning. One may see there are very few standards listed in certain divisions. This serves to identify those areas where standards need to be developed.

Standards are referred to in this Appendix by a short generic content description and number. The standardizing organization and committee responsible for each standard may be identified by the abbreviation associated with the standard number as follows:

- **American National Standards Institute**: ANSI
- **Instrument Society of America**: ISA
- **Institute of Electrical and Electronics Engineers**: IEEE
- **Electronic Industries Association**: EIA
- **Federal Information Processing Standard**: FIPS
- **Military Standard**: MIL
- **National Bureau of Standards**: NBS
- **National Fire Protection Association**: NFPA
- **Comité Consultatif International de Télégraphique et Téléphonique**: CCITT
- **International Organization for Standardization**: ISO

Other abbreviations used are as follows:

- **ACU**: Adaptive Control Unit
- **ATE**: Automated Test Equipment
- **CAMAC**: Computer Automated Measurements and Control
- **CPPP**: Computerized Production Process Planning
- **CRP**: Capacity Requirements Planning
DBS  Data Base System
DCE  Data Communication Equipment
DTE  Data Terminal Equipment
HDLC High Level Data Link Control
IPWICS International Purdue Workshop on Industrial Computer Systems
MRP  Materials Requirements Planning
MRPII Manufacturing Resource Planning
NC   Numerical Control
PCM  Pulse Code Modulation
PROWAY Process Highway (i.e., a particular local area network being developed for manufacturing)

Please supply corrections or additions and request further information from:

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SYSTEMS TRAINING
Operators
Maintenance
Programmers
Quality Assurance
Business
Employee Development
Simulation for Trainers
Management
General

COMPUTER AND COMMUNICATION SYSTEMS
Computer
• Vocabulary Project 26 & 27, ANSI X3K5
• Data transmission vocabulary Project 248, ANSI X3S3.2
• Software engineering terminology IEEE 729

ADP Systems—Formats
• Optional command and format for NC EIA RS-447
• ASCII ANSI X3.4
• ASCII extensions ANSI X3.41
• Numeric value representation ANSI X3.42
• Additional ASCII controls ANSI X3.64
• OCR-A character set ANSI X3.17
• OCR-B character set ANSI X3.49
• Hollerith code FIPS-14; ANSI X3.26
• Magnetic tape labels and files ANSI X3.27
• Structure for magnetic headers
  ANSI X3.57
• EBCDIC (267 character)
• Information interchange formats
  FIPS-20

**Terminals**

• Odd parity for flexowriters
  EIA RS-244
• Subset for NC punched tapes
  EIA RS-358B
• DTE and NC equipment
  EIA RS-408
• DTE and DCE packet mode PCM
  ISO X.25
• DTE and DCE for synchronous PCM
  ISO X.21
• ACU and DTE
  EIA RS-366
• DTE and DCE 37 position connections
  EIA RS-449
• DTE and DCE 25 position connections
  EIA RS-232

**Programs/Languages**

• Software engineering terminology
  IEEE 729
• Guide to the use of ATLAS
  IEEE 771
• APT remarks
  ANSI X3TR
• Guide for the use of Ada®
  IEEE P990
• Software taxonomy
  IEEE P1002
• ATLAS
  IEEE 416
• C/ATLAS
  IEEE 716
• C/ATLAS syntax
  IEEE 717
• FORTRAN I/O and EX industrial extension
  ISA S61.2
• FORTRAN
  ANSI X3.9
• COBOL
  ANSI X3.23
• PL/1
  ANSI X3.53
• PL/S general purpose subset
  ANSI X3.74
• PL/M
• BCPL
• APT
  ANSI X3.37
• APT post-processor interface
  ANSI X3TR
• BASIC
  ANSI X3.60
• RT BASIC extensions
  IEEE 726
• Subroutines for CAMAC
  IEEE 758
• COMPACT/ACTION/SPLIT
  Project 253, BSR X3.94
• Text processing
  Project 203, ANSI X3J6
• APL
  Project 331, ANSI X3J10
• PASCAL
  ANSI X3.97; IEEE 770
• Extended PASCAL
  Project 345, ANSI X3J9
• Ada real-time multi-tasking
  MIL 1815
• Software quality assurance plans
  IEEE 730
• BLISS
• SAIL/PLANNER/CONIVER
• QLISP/INTERLISP/POPLER/POPL-2/LISP-2
• MUMPS XII.1
• IMACS—integrated family for RT control

**Networks**

• S-100 asynchronous nonmultiplexed
  IEEE 696
• Asynchronous 5 MHz
  IEEE 795
• VME bus supports 68000 family
• PROWAY high reliability
• ETHERNET
• Local area networks
• Serial data highway
• Parallel data highway

Displays
• Graphics for ASCII controls
• Digital representation of physical
• Graphical symbols for process displays
• Graphical subsets

Systems
• Design documentation
• Verification
• Reliability measurement
• COPICS—production information control
• PC/DBS—process control data base system

Protocols
• Synchronous data rates
• Serial data bit sequence
• Character structure and parity
• High-speed data rates
• ASCII communication control
• Physical layer
• Data link layer
• Network layer
• Transport layer
• Session layer
• Presentation layer
• Application layer
• Model for open system interconnection
• DDCMP digital data communications protocol
• ADCCP adv. data communication control
• HDLC frame structure

PLANT ENVIRONMENT

Security System

Power

Services

Warehousing

HVAC

Energy Conversion/Reclamation

Fire Protection
Waste Control Treatment
Vents and Hoods
Interior Communications
Timing Standards
Motors and Trucks (for transportation and loading)
Noise Control
Layaway

PRODUCTION SYSTEM SPARES AND REPAIRS

Spares
Repairs
Parts
Repair Systems

PRODUCTION SYSTEM TEST AND SUPPORT

Integration and Assembly
Auxiliary Equipment
System ATE
Alarm Systems
  • Test and evaluation of excitation control
  • Hardware test of digital computers
Calibration
Test Sets
Test Line
Preventative Maintenance
Clean Room

PRODUCTION EQUIPMENT

Machine Tools
  • Intrinsically safe apparatus
  • Electrical and construction
  • Electrical and construction for NC
  • Exchangeable CLDATA
  • NC equipment for asynchronous circuits
  • NC machine tools
  • DTE and NC equipment
  • DTE and DCE packet mode PCM
  • DTE and DCE for synchronous PCM

NFPA 4913
EIA RS-281B
EIA RS-494
EIA RS-491
EIA RS-431
EIA RS-408
ISO X.25
ISO X.21
IEEE 421 A
ISA RP 55.1
• ACU and DTE  EIA RS-366
• DTE and DCE 37 and 9 position connections  EIA RS-449
• DTE and DCE 25 position connections  EIA RS-232

Manufacturing Systems
• Intrinsically safe apparatus  NFPA 4913
• Electrical and construction  EIA RS-281B

Process Systems
• Intrinsically safe instruments  ISA RP 12.6
• Electrical and construction  EIA RS-281B
• Programmable instruments  IEEE 488
• DTE and NC equipment  EIA RS-408
• DTE and DCE packet mode PCM  CCITT X.25
• DTE and DCE for synchronous PCM  CCITT X.21
• ACU and DTE  EIA RS-366
• DTE and DCE 37 position connections  EIA RS-449
• DTE and DCE 25 position connections  EIA RS-232

Material Handling
• Intrinsically safe instruments  ISA RP 12.6
• Electrical and construction  EIA RS-281B

Sensors
• Electrical transducers  ISA S 37.1
• Automatic control ANSI MC 85.1M
• Fluid measurement ANSI MCF-IM
• Process instrumentation ISA S 51.1
• Thermocouples ANSI MC 96.1
• Potentiometric displacement ANSI S 37.12
• Potentiometric pressure ANSI S 37.6
• Piezoelectric ANSI S 37.10
• Strain gage pressure ANSI S 37.3
• Strain gage force ANSI S 37.8
• Strain gage accelerometer ANSI S 37.5
• Turbine flow meters ISA RP 31.1
• Instrument air ISA S 7.3
• Dynamic response ISA S 26
• Analog signal compatibility ISA S 50.1

Interfaces
• DTE and DCE serial data ANSI X3.24
• DTE and nonsynchronous equipment EIA RS-404
• DTE and NC equipment EIA RS-408
• DTE and DCE packet mode PCM CCITT X.25
• DTE and DCE for synchronous PCM CCITT X.21
• ACU and DTE EIA RS-366
• DTE and DCE 37 and 9 position connections EIA RS-449
• DTE and DCE 25 position connections EIA RS-232
• Balanced lines EIA RS-422
• Unbalanced lines EIA RS-423
• CAMAC modular instrument IEEE 583
• I/O channel
• Power control

Transmitters/Receivers

Modems
• Single current contact closure CCITT V.31
• Unbalanced double current CCITT V.28

Cryptographic Systems

Peripherals
• Flexible disk and controller EIA RS-474

PRODUCTION AND PLANT MANAGEMENT

Sales and Marketing

Production Design and Engineering
• Production line
• Production cell
• Flexible manufacturing system
• Group technology
• MICLASS

Manufacturing Engineering

Industrial Engineering
• Installation of safe instruments—Class 1 ISA RP 12.6

Production and Plant Control
• CPPP
• CRP
• MRP
• MRPII

Manufacturing

Quality Assurance
• Guide for quality assurance IEEE P983
• Quality assurance IEEE 730

Shipping and Inventory Control

Personnel Management

Logistics

Configuration Control
• Configuration management IEEE P828
• Configuration management audits EIA CMB 3
• Configuration management for software  EIA CMB 4A
• Configuration management and technical data requirements  EIA CMB 5
• Configuration identification for software  EIA CMB 4-2
• Computer software libraries  EIA CMB 4-3

Hazardous Material Control

Software Quality Assurance Management

• Verification  IEEE P1012
• Reliability measurements  IEEE P982

Systems

• Test documentation  IEEE P829
• Requirements specification  IEEE P830
• Design documentation  IEEE
• Project documentation  Project 16, ANSI X3K1
• Generic guide  ASTM E 622
• Functional requirements  ASTM E 623
• Implementation design  ASTM E 624
• Evaluation  ASTM E 626
• Functional designs  ASTM E 730
• Procurement of turnkey system  ASTM E 731
• Procurement of manufacturing system  ASTM Subcom. E31.08, Project No. E31.0801
• Documenting programs and systems  FIPS 38
• Documenting  ASTM E 627
• Software documentation  ASTM E 919
• Considering user needs  ANSI 10.5