CABLE OR CONDUIT- WHO USES IT AND WHY?

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Abstract:
This paper is a summary of results from a professional survey of people employed in the electrical industry. The purpose is to determine future trends in wiring methods, particularly the use of cabling versus conduit, with special attention to hazardous areas. Trade papers have done a credible and complete job in comparing the economic and technical advantages of installing one wiring system over the other. This paper will instead explore why the U.S. market has not rapidly embraced cable tray, particularly in hazardous areas, and the difference in attitude between the U.S. and Canadian markets. Four distinct groups were surveyed: PCIC members from the United States and Canada and non-PCIC members in the processing industry in the U.S. and Canada. The issues addressed included:

- Engineering, installation and costing decisions made before the wiring system is chosen.
- The impact of the trend toward downsizing and outsourcing of engineering on the wiring systems used.
- Why cable system wiring isn't widely used in Division 2 areas, despite that it's been allowed in classified hazardous areas since 1973.
- Whether the adoption of Article 505 of the National Electrical Code® (NEC) which defines the IEC Zone system will give greater impetus to the use of cable over conduit.
- How large the cost considerations are when deciding between conduit or cable systems.
- The differences in opinions and trends between the U.S. and Canadian markets.

Conclusions:

- Sales of conduit versus cable tray since 1992 reflect general business conditions in the electrical industry rather than a change in market share.
- U.S. and Canadian PCIC members and non-PCIC Canadians tended to have similar responses.
- Canadians unanimously follow the Canadian Electrical Code and CSA approved materials.
- Less than 80% of Americans thought it important for equipment to have third party approvals, compared with 100% of Canadian respondents.
- Canadians and PCIC U.S. members show a preference toward cable systems for future projects.
- Non-PCIC members in the U.S. prefer conduit.
- The trend is for engineering designs to be out-sourced to contractors and engineering design firms. These consultants show a strong preference for conduit systems.
- Those expressing support for the Zone system for hazardous areas lean toward using cable. However, the reverse is not true. Those currently using cable in hazardous areas do not necessarily show a preference for adopting of the Zone concept.
- Canadians are twice as likely to prefer adopting the Zone system for hazardous areas than their American counterparts.
- U.S. non-PCIC members strongly prefer conduit in hazardous areas.
- Canadians prefer the use of Teck cable in hazardous areas.

Introduction:

At the turn of the century, North Americans started converting to the use of electricity in their industries and homes as the main source of power. Contractors found it easy to run the conductors through the existing gas pipelines, previously used to carry gas to the lights. This eventually led to the widespread use of electrical conduit which proved to be a very durable means of installing electrical conductors.

After World War II, shortages of metals led to different installation methods which acted as catalysts for the development of cable tray in Europe. This quickly became the preferred method of routing electrical conductors in commercial and industrial facilities in Europe. Canada also embraced this installation concept and is rapidly installing cable tray in most new installations. Although cable tray methods were introduced in the U.S. after World War II, it has not caught on as quickly.

Evidence of discrepancies in wiring methods in various markets is shown in the current estimated usage of cable versus conduit in Table 1.

TABLE I
Estimated Usage of Cable Tray vs. Conduit

Market	% Usage of Cable Tray	% Usage of Conduit
USA	10	90
Canada	30	70
Europe	>90	<10

Existing Trends:

Growth trend figures for cable tray vs. conduit fittings from

NEMA and the Cable Tray Institute (CTI) are shown in Figure 1. Since the absolute values for conduit fittings are higher than for cable tray, the sales were indexed back to 1992 to show trends rather than absolute values. At this time, increases for both industry segments are a reflection of business conditions in the electrical industry, not one segment taking market share from the other. The trend actually shows current growth of conduit fittings outpacing growth of cable in North America, despite recent changes in the NEC that permits cable in additional applications.

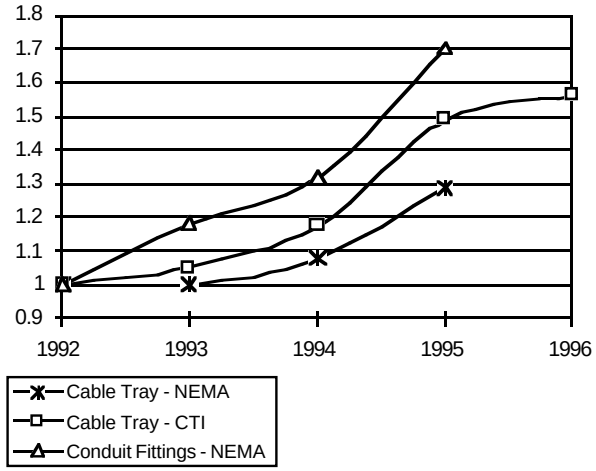

FIGURE 1. Indexed Sales Conduit vs. Cable Tray

Source: Current Industrial Reports, U.S. Department of Commerce, Bureau of the Census

Survey:

The conclusions drawn in this paper are a result of a survey sent to a cross section of 150 PCIC and 350 non-PCIC members in both the U.S. and Canadian electrical industries. (See appendix) The response rate from the survey was slightly more than 25%. Approximately 20% of the total responses were Canadian, which is equivalent to Canadian participation in the PCIC. The results were used to draw conclusions about who uses what wiring system and why; trends in usage during the last 5 years; and attitudes on cable versus conduit usage for future installations. Because over 95% of the respondents represent heavy industry with installations in hazardous areas, the survey also measured the industry's familiarity and comfort level with changes in the electrical codes which allow different classifications of hazardous areas known as the Zone concept.

PCIC member Profile:

The profile of the average PCIC member, who responded to the survey and is employed by an end user, is as follows:

- 24 + years of experience in the industry
- works for a larger company which employs an average of 24,000 people
- works at a local facility which constitutes about 5% of the total work force
- has hazardous areas, with 90% classified as Division 2 and 5% as Division 1.

Survey Results
Code, Conduit and Cable

Code: Indicate the standards that your company follows for electrical installations:
The most notable difference found in the survey between Canadians and Americans is that Canadians follow the Canadian Electrical Code 100% of the time without any deviations. Although 100% of PCIC U.S. members follow the NEC, one third also accepted IEC standards.

Third Party Approvals: The electrical material installed in my facility or that is specified must have third party approvals.
Canadians were also unanimous that equipment must have third party approvals. Americans were less strict, with only 80% of U.S. PCIC members and 70% of non-PCIC members requiring approvals. These answers demonstrate the Canadian adherence to the CEC and CSA type approvals on equipment. PCIC U.S. members, on the other hand, showed greater latitude in accepting IEC standards, probably a reflection of more international plant locations.

Cost of Tray Cable: Tray cable systems have a lower initial material cost. Conduit is cheaper to install than tray cable.
These questions investigated the costs in engineering and installing conduit versus cable systems. While each group was neutral about the cost of materials of conduit versus cable tray, there was general agreement that cable tray is less expensive to install.

Material Cost - Conduit Is Less Expensive to Install			
	Agree	Disagree	No opinion
U.S. non-PCIC		x	
U.S. PCIC		xx	
Canada non-PCIC		xx	
Canada PCIC		xx	

Note: "X" is disagree; "XX" is strongly disagree

Material Cost - Cable Tray Has Lower Material Cost			
	Agree	Disagree	No opinion
U.S. non-PCIC			x
U.S. PCIC			x
Canada non-PCIC	x		
Canada PCIC			x

Engineering Costs: A cable tray/conduit system is an engineering cost. Installation of a cable tray system requires engineering expertise.
Is one system more complicated to install than others? Conduit has been the more conventional installation method in the past, and most North American engineers and contractors are familiar with conduit installation methods. Cable tray manufacturers offer software which

now helps in the engineering of the tray systems implying that design assistance is needed. When asked if cable tray required engineering expertise, or if this engineering would keep someone from using cable tray, the results were mixed. Canadians felt cable tray systems required engineering expertise, but this engineering expertise did not keep them from using the cable tray systems. Americans had no opinion about the engineering of cable tray. If expertise is required, it is not a deterrent to using cable tray systems.

Installing Cable Tray Requires Engineering Expertise			
	Agree	Disagree	No opinion
U.S. non-PCIC			x
U.S. PCIC			x
Canada non-PCIC	x		
Canada PCIC	x		

Engineering for Cable Tray Keeps Us from Using More Cable			
	Agree	Disagree	No opinion
U.S. non-PCIC		x	
U.S. PCIC		x	
Canada non-PCIC		xx	
Canada PCIC		xx	

Protection: Conduit offers better protection than tray cable.
When asked about protection of wiring, most respondents felt strongly that conduit offered better protection than cable tray except for the Canadian PCIC members who were neutral in their response. This may be a large factor why conduit is still used in hazardous areas, especially for drop downs.

Conduit Offers Better Protection than Cable Tray			
	Agree	Disagree	No opinion
U.S. non-PCIC	xx		
U.S. PCIC	x		
Canada non-PCIC	xx		
Canada PCIC			x

Future use of Cable Tray: For future expansion, how likely are you to use cable/conduit?
This question was asked in a number of different ways. When asked whether cable tray would be used for future installations, Canadians said they are very likely to use cable and not likely to use conduit. U.S. members were mixed. PCIC members said they were likely to use cable and were neutral about conduit. Non-PCIC members were more likely to use conduit and undecided about cable tray systems. Over 30% of U.S. respondents indicated that they are likely to use both systems, which implies that there are specific applications for both wiring systems in their facilities. Following is a summary by profile group as to future preferences for cable and conduit installations:

Will Use Cable for Future Installations			
	Agree	Disagree	No opinion
U.S. non-PCIC			x
U.S. PCIC	x		
Canada non-PCIC	xx		
Canada PCIC	xx		

Will Use Conduit for Future Plant Expansions			
	Agree	Disagree	No opinion
U.S. non-PCIC	xx		
U.S. PCIC			x
Canada non-PCIC		xx	
Canada PCIC		xx	

While all Canadians feel strongly about the use of cable, there is a notable difference among U.S. respondents. PCIC members, in general, are inclined to use cable while non-PCIC members have a random pattern of responses. (Figure 2) Most are neutral or do not know which wiring system they will use in the future. There are as many strongly in favor of cable as they are opposed to it.

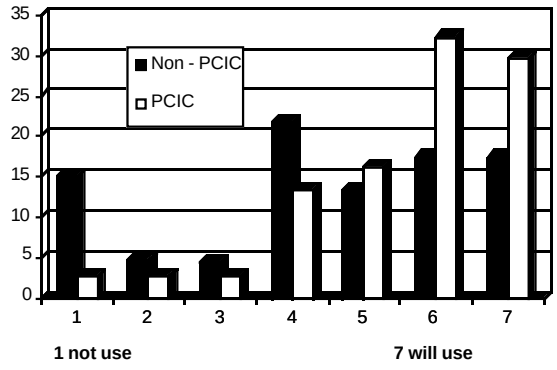

FIGURE 2. Future Use of Cable in the USA - PCIC vs. Non PCIC

What Groups Use Conduit?

The 4 user groups represented by the survey are oil refineries, chemical plants, pulp & paper mills and industry consultants. Chemical and oil refinery groups show a polarization of opinions for and against the use of conduit. Figure 3 shows responses by users in oil refineries and chemical plants about the future use of conduit. Opinions widely vary in these industry groups, with as many agreeing as there are disagreeing about the use of conduit.

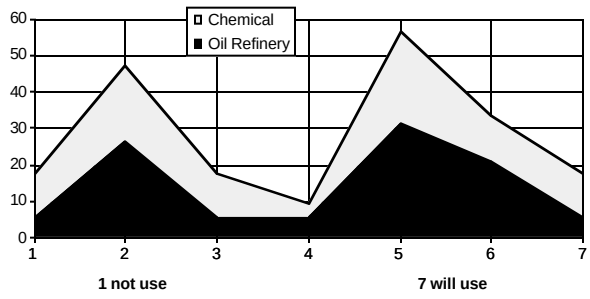

FIGURE 3. Use of Conduit by Petrochemicals

The Pulp and Paper Industry has strong feelings toward cable tray. None of those surveyed from this group indicated a preference for conduit. (Figure 4) However, conduit is still the installation method of choice for outside consultants. (See Figure 5) As firms continue to out-source their engineering work, consultants will have an effect on which wiring system is used: either conduit or cable systems.

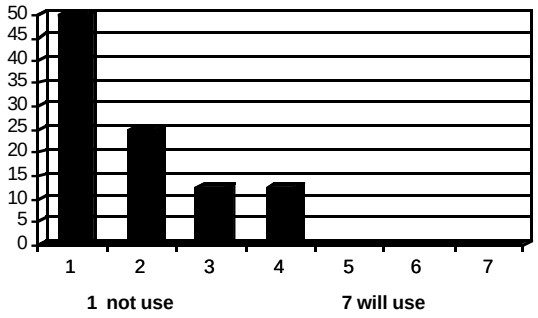

FIGURE 4. Use of Conduit by Pulp & Paper

Alternative Wiring Methods: Do you see a greater. lesser or the same application for cable tray/non-metallic conduit/open wiring in the future?

There are other variations of these wiring methods available which were surveyed relative to cable tray. These were the use of non-metallic conduit and open wiring which is open ended conduit without the fittings. Both wiring systems are widely used in parts of Europe. When measuring whether there will be greater use of these methods; over 50% said yes to cable tray but only 15% indicated they would use more non-metallic conduit and only 11% saw a future application for open wiring.

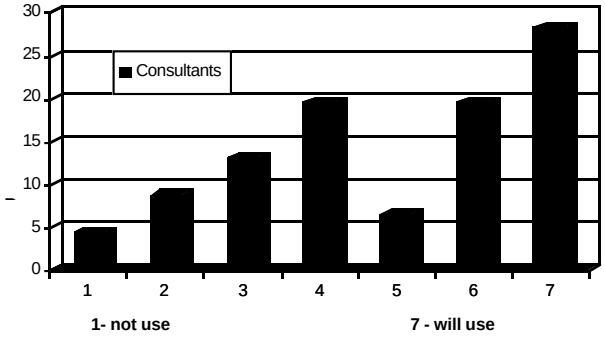

FIGURE 5. Use of Conduit by Consultants

Survey Results - Hazardous Areas

Hazardous Areas -What will the future installations look like? For future expansion into hazardous areas, how likely are you to use cable/conduit?
The use of metal clad or Teck cable is very high in Canada for hazardous area installations. However U.S. non-PCIC respondents strongly prefer conduit. PCIC U.S. respondents do not show a strong preference either way.

Will Use Metal Clad for Future Expansion Hazardous Areas			
	Agree	Disagree	No opinion
U.S. non-PCIC		xx	
U.S. PCIC			x
Canada non-PCIC	xx		
Canada PCIC	xx		

Zone concept: For future expansions, how likely are you to adopt the zone system?
The one issue, where all profile groups were neutral, was about whether they would adopt the Zone concept for hazardous area classification over the current Division system.

Will Adopt Zone System			
	Agree	Disagree	No opinion
U.S. non-PCIC			x
U.S. PCIC			x
Canada non-PCIC			x
Canada PCIC			x

We would conclude from the large percentage of responses that were neutral on adoption of the zone concept, that many do not fully understand the new classification system. In Figure 6, responses were sorted, and the results show an almost perfect bell shaped curve indicating the random nature of the responses.

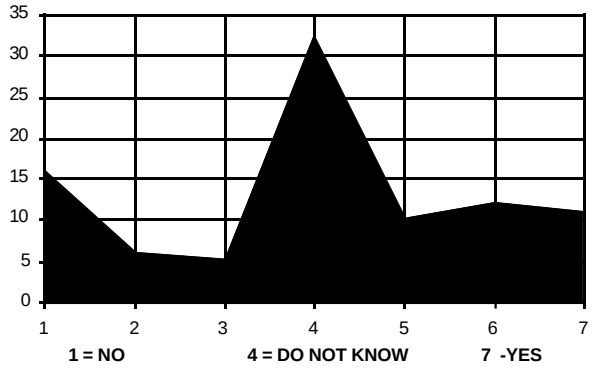

FIGURE 6. Will You Adopt the Zone Concept?

Who are the Dissenters?

While the vast majority of respondents were neutral or undecided about whether to adopt the Zone system, it is interesting to note those groups which felt strongly one way or the other: (the 1 & 2 responses versus 6 & 7). A greater percentage of Canadians voted in favor of while U.S. responses were 2:1 against the Zone Concept.

When the responses are looked at by each country the results are as follows:

Will Adopt The Zone System (%)			
	Agree	Disagree	No opinion
U.S.	15	14	71
Canada	43	15	42

This data sorted by country shows that Canadians are 3 times more likely to use the Zone classification system while the majority of Americans are undecided. The Canadian response may be influenced by future Canadian Electrical Code changes being discussed which give preference to the Zone system. With most responses being neutral, what direction will the PCIC give to the rest of the electrical industry? This question should be measured over the next decade.

Cable Tray vs. Zones:

What is the correlation between the use of cable and adoption of the Zone concept. When these results are cross-tabulated, two mutually exclusive results are clear:

1. Those who are inclined to use the Zone concept, will use more cabling,
2. However, those who presently use more cable, are not inclined to adopt the Zone concept.

This implies that the wiring method currently employed will not be a determining factor in adoption of the Zone concept.

Survey Results
Engineering Design Work

Where will decisions be made in the future? Where is the current engineering/design work performed today compared with 1990?
There is a sudden and strong shift away from central engineering to contractor design/ build. Other categories of engineering such as local and outside design consultants remained the same. See Figure 7.

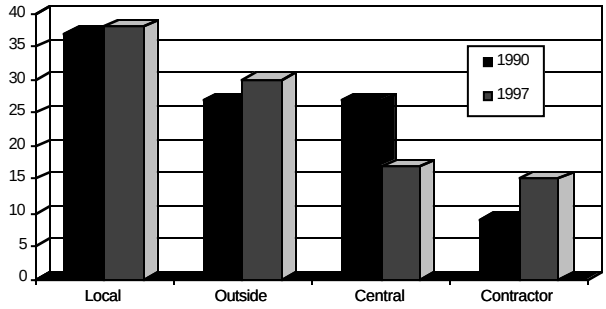

FIGURE 7. Where Installations Are Engineered

Breaking out this data between the Central Engineering and Contractor Build illustrates the changes more dramatically: See Figure 8.

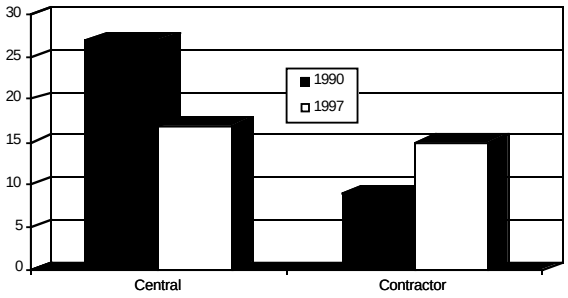

FIGURE 8. Change in Engineering

How Well Is the Code Understood? My country's code does/does not allow the use of cable tray in Division 2 areas?
To test the awareness of code requirements and code changes, questions were asked about the use of cable in Division 2 areas and if metal clad cable can be used in Division 1 areas. Under the NEC, cable has been allowed in Division 2 for more than 20 years, while metal clad in Division 1 is a recent Code change.

More than 95% of the PCIC respondents were aware of this change for Division 2. However, only 15% of respondents from the U.S. that were non-PCIC members answered this incorrectly. This is a good indication that PCIC members are more aware of code requirements for hazardous areas.

My country's code allows/does not allow for use of metal clad cables in Division1?
Asked whether metal cable could be used in Division 1 areas, less than half of the respondents answered this correctly.

Can Use Metal Clad Cable in Division 1 Areas (%)			
	Agree	Disagree	No opinion
U.S. non-PCIC	36	5	59
U.S. PCIC	58	5	37
Canada non-PCIC	53	0	47
Canada PCIC	44	22	34

Future Trends

Over the last decade the debate has raged whether the electrical industry, and specifically the industries represented by the PCIC, should change the electrical standards, practices and installations. For some, this change will never occur; and for others, it can not occur soon enough. The first indication of change will be wiring methods.

Canadians, who participated in this survey, voted in unison about standards and the use of cable tray. As a group, they were more receptive to adopting the Zone concept. Americans have more diverse opinions. Many are comfortable with their current installation methods; others are driven to change. When PCIC and non PCIC members agree, it is about an objective measurement such as costs, protection or the technical merits of engineering. When their opinions differ, it concerns future practices.

When responses are tabulated as *no opinion* or fall into the classic bell curve, clearly a consensus will be difficult to reach. To reach agreement one must examine the driving forces that people follow in this industry: safety, costs and simplicity. Safety is constantly built into the codes and standards as well as the equipment that is manufactured and installed. While costs are easier to measure, they are not always the main driving force that we think they are. Evidence of this is that while most agreed that cable tray offered cost advantages over conduit, many Americans still preferred using conduit. Is this because conduit offers greater protection, or because they are more comfortable using it at any cost?

Typically, when a consensus cannot be reached and all else fails, simplicity sells. This will become more apparent if and when companies move to the Zone system of classifying hazardous areas. The debate will continue over safety and costs savings, but at the end of the day, the success of the Zone system will be measured by its simplicity. If the Zone system is easy to understand; easy to apply; easy to purchase approved equipment; easy to install; and easy to be approved, it will be a success. If it becomes complicated by code changes and approvals, it is doomed to failure. Simplicity will be the one deciding factor which will move the majority from their neutral vote to a consensus.

APPENDIX A

PCIC SURVEY

1. Please indicate the standards that your company follows for electrical installations:

_____ National Electrical Code (NEC)
_____ Canadian Electrical Code (CEC)
_____ International Electrotechnical Commission (IEC)
_____ Other (specify) _____

2. The electrical material installed in my facility or that I specify must have third party approval.
ie. UL, CSA, ETL.

No _____ Yes _____
Which one(s)?_____

3. Please indicate the extent to which you agree or disagree with the following statements:

(1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neutral, 5 = somewhat agree, 6 = agree, 7 = strongly agree)

		SD			**Neutral**			**SA**
i	Tray cable is used more often than conduit.	1	2	3	4	5	6	7
ii	Conduit is cheaper to install than tray cable.	1	2	3	4	5	6	7
iii	Tray cable systems have a lower initial material cost.	1	2	3	4	5	6	7
iv	For future installations I will use tray cable.	1	2	3	4	5	6	7
v	Conduit offers better protection than tray cable.	1	2	3	4	5	6	7
vi	Installation of a cable tray system requires engineering expertise.	1	2	3	4	5	6	7
vii	A cable tray is an engineering cost.	1	2	3	4	5	6	7
viii	A conduit system is an engineering cost.	1	2	3	4	5	6	7
ix	My company will adopt the zone system for hazardous areas.	1	2	3	4	5	6	7
x	Engineering needed to design a cable tray system keeps us from using cable.	1	2	3	4	5	6	7
xi	My company uses conduit to match its existing conduit system.	1	2	3	4	5	6	7
xii	Installing a wiring tray is a smaller engineering cost than installing conduit.	1	2	3	4	5	6	**7**

4. What percentage of your electrical wiring utilizes conduit?

_____ Less than 20%
_____ 20 to 80%
_____ 80 to 99%
_____ 100 %

5. Do you have any Class I or Class II hazardous classified areas in your facilities?

_____ Yes
_____ No

If No, please go to question 9.

6. What percentage of those classified areas is:

Division 1? _____ % Division 2? _____ %

7. Please indicate the extent to which you agree or disagree with the following statements:

(1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neutral, 5 = somewhat agree, 6 = agree, 7 = strongly agree)

		SD			Neutral			SA
i	My country's code does not allow the use of cable in cable tray in Division 2 areas.	1	2	3	4	5	6	7
ii	My country's code allows for use of metal clad cables in Division 1 areas.	1	2	3	4	5	6	7

8. What is current percentage use of cable or conduit in your Class I or Class II hazardous areas?

Cable _____%

Conduit _____ %

9. For future expansion, how likely are you to use:

(1 = very unlikely, 2 =unlikely, 3 = somewhat unlikely, 4 = undecided, 5 = somewhat likely, 6 = likely, 7 = very likely)

		UnLikely			Undec.			Likely
i	Conduit.	1	2	3	4	5	6	7
ii	Cable.	1	2	3	4	5	6	7

10. For future expansion into hazardous areas, how likely are you to:

(1 = very unlikely, 2 =unlikely, 3 = somewhat unlikely, 4 = undecided, 5 = somewhat likely, 6 = likely, 7 = very likely)

		UnLikely			Undec.			Likely
i	Use metal-clad cable.	1	2	3	4	5	6	7
ii	Use conduit.	1	2	3	4	5	6	7
iii	Use tray cable.	1	2	3	4	5	6	7
iv	Adopt the new Zone system.	1	2	3	4	5	6	7

11. In 1990, please indicate what percentage of your facility's electrical engineering/design was done:

_____ % Locally at the facility

_____ % Central engineering function

_____ % Outside design consultant

_____ % Contractor design/build

_____ % Other (specify)

100%

12. Please indicate what percentage of your facility's CURRENT electrical engineering/design is done:

_____ % Locally at the facility

_____ % Central engineering function

_____ % Outside design consultant

_____ % Contractor design/build

_____ % Other (specify) _____

100%

13. For the next three questions, please circle either greater, lesser or same and then tell us why.

i. In your opinion do you see **GREATER, LESSER**, or the **SAME** application for cable tray in the future? Why?

_____

_____

ii. In your opinion, do you see a **GREATER, LESSER**, or the **SAME** application of non-metallic conduit in the future? Why?

_____

_____

iii. In your opinion, do you see a **GREATER, LESSER**, or the **SAME** application for open wiring in the future? Why?

_____

_____

14. What is your job description? (Check one)

_____ Design Engineer
_____ Electrical Engineer
_____ Electrician
_____ Consultant
_____ Contractor
_____ Other (specify) _____
_____ Maintenance

15. How many years have you worked in this industry? _____

16. How many people does your company employ? _____

17. If you have more than one facility, how many are employed at your facility? _____

18. What type of facility do you have? (check one)

_____ Wastewater Treatment
_____ Pharmaceutical
_____ Oil Refinery
_____ Chemical Plant
_____ Food Processing
_____ Pulp or Paper Mill
_____ Automotive
_____ Other (specify) _____

19. Please send me a copy of your paper.

Company Name _____

Name _____ Title _____

Address _____

City _____ State _____ Zip _____

Phone _____ Fax _____ email _____