The Vinyl Institute
A Division of The Society of The Plastics Industry, Inc.

Roy T. Gottesman
Executive Director

August 31, 1990

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Sherr M Carr

TO: VI Pipe Resource Organization

RE: Business Communications Company Report On "The Scope For Plastics in DWV Pipe In High-Rise Buildings"

As you were advised in my memorandum of August 6th which contained the agenda for the upcoming meeting of PRO on September 6th, enclosed is a copy of the report prepared by Business Communications Company mentioned above.

Dr. Peter J. Mooney of Business Communications Company will give a presentation on the results of this study at our next meeting.

Please try to review this report prior to the meeting, so that we can have a full discussion with Dr. Mooney about it.

Sincerely yours,

RTG/pmb

CTL029742

FINAL REPORT

THE PROSPECTS FOR PLASTICS IN HIGH-RISE RESIDENTIAL AND NON-RESIDENTIAL PIPING PROGRAMS

Submitted to:

Pipe Resource Organization (PRO) Committee
The Vinyl Institute
Wayne, New Jersey

Prepared by:

Plastics Research Division
Business Communications Company
Norwalk, Connecticut

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FOREWORD

Business Communications Company (BCC) was initially contacted by the Pipe Resource Organization (PRO) Committee of the Vinyl Pipe Institute in early February 1990 to determine whether it would be feasible to research the prospects for plastic DWV pipe in the construction of high-rise buildings. We indicated at that time that the best available data on the annual volume and value of building construction of all types are those collected and published by the F. W. Dodge division of McGraw-Hill. We also indicated that the annual subscriptions for the F. W. Dodge data services are relatively expensive - of the order of $20,000-$30,000. BCC proposed to devote 3-5 days exploring alternative sources of such construction data and making very preliminary estimates of the likely volume and value of DWV pipe in high-rise buildings in recent years.

The PRO Committee subsequently requested that BCC resubmit a proposal for a more detailed study based on the following requirements:

1) Survey and quantify the volume of high-rise building construction (residential and non-residential) over the recent past and projected to the year 2000.
2) Survey and quantify the different DWV pipe materials used in these high-rise buildings.
3) Evaluate the extent to which the regional (model) and local (state/municipal) plumbing and building codes impinge on DWV pipe material selection in high-rise building construction.
4) Determine the scope for plastic DWV pipe if these codes could be amended to facilitate the use of plastics in high-rise buildings.
5) Provide a written and an oral report to the PRO Committee membership on (1)-(4) above.

On March 15 BCC submitted a proposal to spend 17 days covering the issues as listed in (1)-(4) above and 1 day for the oral executive briefing for the PRO Committee membership. On March 21, at the request of the PRO Committee, we amended that proposal to include a determination of the scope for other plastic plumbing pipe in high-rise building construction beyond the DWV pipe applications. We indicated that a secondary issue to be researched as we interviewed key industry participants and as we generated estimates for DWV pipe would be the overall amount of plastic plumbing materials (e.g., hot and cold water feeds) that are and could be used in these high-rise buildings. The number of days to be devoted to the research and report-writing stages of the proposed research program remained the same. This amendment was agreed, and on May 29 BCC commenced the research program.

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As our research program proceeded, it became obvious that there is in fact significant scope for plastic pipe of all types in high-rise building construction, but that changes would first have to come in the model and local building codes, in mechanical engineers' perceptions, and in the cost/performance of the plastic pipes of various types. It also became obvious that whereas the codes cover the scope for metallic and non-metallic pipes of all types (e.g., DWV, hot and cold water feeds, water sprinkler piping, air conditioning piping, etc.), the market for pipe (both metallic and non-metallic) is largely segmented by pipe application. This is particularly true of DWV pipe where there are several dedicated metal (cast iron) and plastic (PVC and ABS) DWV pipe manufacturers with little or no exposure in other building pipe product lines.

Thus, throughout our research program, including interviews with over 50 company and government officials, we raised the issue of total plastic pipe prospects in high-rise building construction. However, we delved in greatest detail (and, accordingly, we report in greatest detail) on the DWV pipe category insofar as

1) this was the original thrust of the investigation,
2) this was a well-defined pipe application with a manageable number of key players to be identified and interviewed in depth in the time available, and
3) our initial survey correspondents in the model code-writing agencies and building-related associations considered DWV pipe to be an ideal foundation on which to base an eventually comprehensive challenge to the current restrictions on plastic pipe of all sorts in high-rise buildings.

In this report, therefore, we cover in detail the current and likely future economic and regulatory environment for plastic DWV pipe in high-rise buildings. Then, drawing on the data and insights gained from this pipe sub-market, we provide a separate assessment of the implications for plastics as a whole competing against metals in all types of pipe used in high-rise residential and non-residential buildings. Ideally, an initial campaign to get plastics specified for high-rise building DWV pipe, if successful, should be quickly followed by a similar challenge to the metal pipe fabricators in all other high-rise building pipe applications.

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INTRODUCTION

The manufacturers of plastic pipe have been very successful over the past 30 years in penetrating many of the pipe markets formerly dominated by non-plastic ("traditional") materials such as metals (steel, cast iron, copper) and non-metallics (concrete and clay). This process of replacement of traditional piping materials has been driven by the superior cost, design freedom and overall performance of extruded plastic pipe and injection molded pipe fittings.

One pipe sub-market that has not yet yielded to the plastics revolution in piping systems is pipe in high-rise (3 stories and more) buildings. The barriers to penetration here are diverse:

1) local and national (model) building codes that place restrictions on the use of combustible materials in the construction of fire-rated buildings of varying sizes, types and occupancies,
2) parallel restrictions promulgated by standards-setting organizations (e.g., ASTM, NFPA) that the model code organizations rely on and reference,
3) resistance by the plumbers and their union to modifing work rules predicated on the use of traditional piping materials, and
4) conservatism on the part of mechanical engineering firms that specify materials for the piping systems that building contractors install in buildings.

As a result, plastic pipe is the exception rather than the rule in both low-rise non-residential and high-rise residential and non-residential building programs.

The Pipe Resource Organization (PRO) Committee of the Vinyl Institute has asked Business Communications Company (BCC) to research this issue and to determine

a) the precise nature of the barriers to plastics in high-rise building DWV and plumbing pipe programs,
b) possible routes to overcoming these barriers, and
c) the potential gains that could be expected from successfully overcoming these barriers.

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The BCC research program has both quantitative and qualitative aspects. On the quantitative side, BCC has been asked to determine the current size of the market for DWV and plumbing pipe in buildings of all types, the current shares of this market held by plastics and alternative piping materials, and the potential opportunities to the plastic pipe (and resin) companies if some or all of the high-rise pipe market could be converted over to plastics. On the qualitative side, BCC has been asked to consult with officials in the field at all levels (plastic and non-plastic pipe manufacturers, pipe material specifiers and end-users, officials at local and national organizations involved in the writing, review and enforcement of regulations/codes impinging on pipe material selection) to determine the background to these restrictions to the use of plastic pipe and the possible routes to overcoming these restrictions.

As recommended in our Research Study Proposal of March 1990, BCC has undertaken an extensive review of the relevant literature and data and conducted a comprehensive series of consultations with key market players in order to deliver realistic quantitative and qualitative assessments to the PRO Committee. The research and report-writing stages of this project were undertaken from late May through early July 1990. The BCC analyst conducted over 50 in-depth interviews (by phone and in person) with leading personnel in this and related fields. The conclusions and recommendations that BCC offers to the PRO Committee in this Final Report will be discussed at an executive briefing at the Vinyl Institute offices in Wayne, New Jersey on September 6, 1990.

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CONCLUSIONS

1. In this research program we focused on the prospects for plastics in the following types of pipe systems in high-rise building construction:

- plumbing pipe
- DWV/soil pipe

2. There are several materials contending for the plumbing pipe applications - namely,

- copper
- steel (galvanized and stainless)
- plastics (PVC, CPVC, polybutylene)

Overall copper dominates with 93% of all water distribution piping, plastics hold a 4% share, and galvanized steel the residual 3%. The share of stainless steel in plumbing pipe is negligible. In high-rise buildings copper once again dominates, galvanized steel holds a share of less than 5%, and the shares of plastics and stainless steel are negligible.

3. We estimate that as of 1989 there were 46-92 million feet of mainly copper plumbing pipe in high-rise building construction. If, in theory, plastic pipe could replace copper (and galvanized steel) in this construction sub-market, the result would be

- an additional 18-37 million pounds of resin sold
- an additional 46-92 million linear feet of small (1/2-3/4") pipe extruded
- an additional $28-55 million of pipe sales realized.

If we include the additional demand generated for plastic plumbing pipe fittings, the total potential is of the order of $35-65 million.

4. There are four materials that contend for the drain-waste-vent (DWV) segment of the pipe business--namely,

-aluminum
-cast iron
-copper
-plastics (ABS and PVC)

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Copper, which used to hold a significant (and growing) share of this business in the decades immediately following WWII, today only holds a minor and diminishing share, and it is not being heavily promoted. Aluminum, which also was a contender for this application in the late 1940s and 1950s, is today a minor player in this market, but at least one aluminum manufacturer (Alcan) is currently intensifying its promotional efforts. That leaves cast iron and plastics with the bulk of the DWV pipe business.

5. As of 1989, there were 6 major manufacturers of cast iron DWV (soil) pipe and 25-30 major manufacturers of plastic DWV pipe. Two U.S. companies and at least one Canadian company are prominent in the production of both cast iron soil pipe and plastic DWV pipe. Last year these and other market players consumed 621 million lbs. of plastics and 721 million lbs. of cast iron in the fabrication of DWV/soil pipe. Converting these figures into linear pipe length equivalents, plastic pipe holds a 78% share and cast iron pipe the residual 22% share of this market. These shares have held roughly constant over the past five years (1984-1989).

6. We estimate that as of 1989 there were 22-44 million feet of mainly cast iron DWV pipe in high-rise building construction. If, in theory, plastic pipe could replace cast iron in this construction sub-market, the result would be

- an additional 39-79 million pounds of resin sold
- an additional 22-44 million linear feet of large (4-6") diameter pipe extruded
- an additional $19-37 million of pipe sales realized.

Again, if we include the additional demand generated for plastic DWV pipe fittings, the total potential is of the order of $25-50 million.

7. The factor that is conventionally pointed to in explaining this stark exclusion of plastics from high-rise buildings is concern over the flammability and toxicity of plastic pipe in possible fire scenarios. However, in reality there are four sets of factors at play here--namely,

i) codes,
ii) coercion,
iii) conservatism, and
iv) cost/performance.

We examined each of these factors in detail in the context of DWV pipe.

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8. Codes. The national (model) codes that mechanical engineers observe in selecting materials and designing systems for building programs are frequently alluded to as the principal barriers to plastics (and other combustible materials) in high-rise DWV pipe. Yet, while there is unarguably some truth to this contention, the codes by themselves are not the problem. First of all, there is nothing in the three (BOCA, ICBO/IAPMO, SBCCI) plumbing codes that warrants the exclusion of plastics. The issue of combustibility is in the domain of the building officials, and, therefore, one has to scrutinize the precise language and logic of the building codes. Secondly, in each of the three model building codes there are detailed references to the desired fire-resistive construction methods and materials to be used in high-rise buildings of varying types (e.g., Types I-V) and occupancies (e.g., Educational, Business, Residential, etc.). Yet the writers of all these codes (which are reviewed on a regular 3-year cycle) have gone to great lengths to point to the latitude that they wish to encourage in the use of traditional and new ("innovative") materials in piping and other systems. While they do not yield in terms of maintaining minimum levels of fire protection, they all emphasize that alternate materials and methods of construction may be approved by the local building officials provided these alternates can deliver equivalent performance in terms of quality, strength, effectiveness, fire resistance, durability and overall safety. The code writers and enforcers contend vigorously that they are moving away from specification-based standards to performance-based standards so that any material can (in theory) compete. But these new materials and the resultant pipe configurations must be tested and approved by ASTM and other standard-setting organizations for flame spread, smoke release, etc.

9. Coercion. There is a tendency in the plastic pipe industry to point to the plumbers and their union (the UA) as culprits in the exclusion of plastics from high-rise DWV piping programs. There is no question that the plumbers, with longstanding work rules predicated on the use of skilled labor-intensive cast iron soil pipe, have been active in defending their jobs since plastic pipe is fundamentally a labor-saving innovation involving lower skill requirements at the point of installation. There is also no question that the plumbers and their union have historically exercised greater political influence on the plumbing and building code authorities than the plastic pipe companies. However, plumbers union power was not sufficient to prevent the nearly total replacement of cast iron by plastics in residential plumbing systems. Moreover, studies in the past conducted by the Federal Government into possible antitrust violations in this field failed to come to such a conclusion, and our more limited sample survey also fails to come to such a conclusion. The power of the plumbers union is still strong in numerical terms, but their power to influence modern building code writers and enforcers at the local level is largely waning.

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10. Conservatism. Our survey results point to a large measure of conservatism among the mechanical engineering community when it comes to the specification of materials for pipe and other parts in high-rise buildings. Cast iron pipe to a mechanical engineer connotes adequate or even excessive structural strength, flow characteristics, mass for desirable acoustics, corrosion resistance and fire performance. They are all aware of the fact that plastic DWV pipe is less expensive to install than cast iron soil pipe. However, in the absence of pressure from the local authority or the private sector company financing and managing the project, the mechanical engineer will generally adopt the safe route of specifying the "tried-and-true" which in this instance is cast iron, not plastics. To the typical mechanical engineer, either intuition tells him to avoid additional flammable plastics in his design or he has seen/heard stories where plastic pipe contributed to a fire situation. Unless the cost advantages and the safety record of plastic pipe are brought home forcibly, the mechanical engineers, with the risk of insurance liabilities as an over-arching concern, will opt for conservatism every time and leave creativity to the architects.

11. Cost/performance. In the final analysis, whereas codes, coercion and conservatism play major or minor roles, the breaching of the current restrictions to plastic DWV pipe will have to come through superior cost/performance (as in any other market). For many mechanical engineers, either the performance of plastic DWV pipe doesn't come up to their standard or the cost advantage to be gained by switching to plastics is limited or illusory. Performance in the area of DWV pipe is multi-faceted: it relates to

a) fire performance (unprotected PVC or ABS pipe will not comply with the 1-4 hour fire rating specified),
b) dimensional stability (plastic pipe is less rigid than cast iron and it has a higher coefficient of expansion and contraction, so it requires more hangers and supports),
c) acoustics (with less mass than cast iron, even foamed plastic DWV pipe is noisier in operation),
d) maintenance (plastic pipe is less amenable to mechanical and chemical cleaning), and
e) others.

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To the extent that some of these performance deficiencies can be overcome, plastics may be able to penetrate some of the high-rise DWV pipe business. However, unless all of them can be overcome (and that seems unlikely without eliminating the existing cost advantage of plastics), there will always be some upper bound in the potential penetration of the high-rise DWV pipe business.

12. In the final analysis, the majority of the officials consulted for this survey either volunteered the opinion or concurred in the opinion offered that the exclusion of plastics from high-rise DWV pipe programs is 50% due to code restrictions and the other 50% is due to real/perceived cost/performance deficiencies that make the mechanical engineers and building contractors unwilling to challenge these codes. If the cost/performance problems can be successfully addressed, then most or all of the code restrictions could be overcome through a coordinated industry education and promotion initiative.

13. There are a number of lessons for the plastic (PVC and ABS) resin pipe manufacturers to learn from other pipe and tubing markets where plastics processors--counter-intuitively--overcame the engineering preferences for metals. Here in this country producers of plastic electrical conduit had faced an equally daunting panoply of market and institutional impediments to plastics, and yet they overcame them. And in Europe we are just beginning to see the long-term efforts of plastic pipe fabricators to penetrate offshore oil rig piping systems being rewarded. In each case, the metals mentality was challenged, new fire protection methods were devised and tested and approved, and codes/standards were modified to permit the cost/performance advantages of plastics to be realized.

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RECOMMENDATIONS

1. The PRO Committee and the other plastic pipe industry participants have to determine, first and foremost, whether plastics have genuine cost/performance deficiencies in high-rise piping or whether the exclusion of plastics from these applications is simply the result of institutional discrimination, misrepresentation and ignorance of the facts. If the latter is the case, then the PRO Committee and other industry players will have to resort to judicial challenges, intensive public relations efforts, and extensive education to change the current mind-set among local code officials and local mechanical engineers. However, if, as we believe, there are genuine cost/performance deficiencies that would obtain regardless of code restrictions or union politics or mechanical engineers' conservatism, then these deficiencies have to be addressed in order to realistically anticipate penetrating this pipe market segment.

2. Obviously, the efforts to be made to correct these misperceptions or cost/performance deficiencies have to be related to the potential gains to be made in this pipe market segment. We have calculated the total potential for plastic DWV pipe in high-rise building construction at $19-37 million ($25-50 million if DWV pipe fittings are included). The total potential for plastic plumbing pipe in these buildings is $28-55 million ($35-65 million if plumbing pipe fittings are included). Thus, even if half of these market segments could be captured, the effort would seem to warrant the expenditure of several million dollars by the PRO Committee and other plastic pipe industry participants. However, this program would have to be coordinated among the various interested parties. The individual programs by the PPFA and others to date have not succeeded in opening up these market segments.

3. The DWV pipe market should be aggressively addressed first and foremost. The primary cost/performance deficiencies in plastic DWV piping for high-rise buildings are well-known--that is,

a) the flammability and smoke emission rates of the principal plastics used (ABS and PVC), and
b) the excessive noise associated with the operation of tall columnar thin-wall plastic DWV pipe.

Each of these problems has to be solved without compromising the overall advantageous long-term economics of plastic pipe and pipe fittings.

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4. The first problem to be faced is flammability and smoke emission. The relevant context here is the flammability and smoke emission potential of the whole piping system, not the individual pipes and fittings per se. In other words, the reason why plastic piping (DWV and other) is prohibited from most multi-story buildings is not that individual pipe lengths will burn or generate smoke upon burning. Rather, it is that such smoke may be passed through fire-resistive floor/ceiling openings to endanger the lives of occupants of the upper floors, further away from the means of egress from the building. So, the development of cost-effective and code-approved fire-stopping devices seems to be imperative in overcoming current code restrictions on combustible piping materials and mechanical engineers' conservatism. There are such devices being manufactured today, but they are very expensive. Alternatively, fire-protective costings or wraps can be used to achieve the 1-4 hour fire ratings required, but again industry observers claim that this option would probably eliminate the cost-effectiveness of plastics versus cast iron in DWV (and other) pipe.

5. The second problem is largely in the realm of mechanical engineering (rather than codes), and that is acoustics. The plastic pipe manufacturers themselves admit to this problem, and it may be very difficult to solve in very tall buildings where water and waste cascade down 80-100 feet of DWV pipe. Even foam core plastic pipe is apparently unable to correct this problem sufficiently, and adding further mass to the pipe wall may again compromise the cost advantage of plastics. Over and beyond the noise problem, mechanical engineers allude to the high head pressure built up within such long vertical pipe runs that may exceed the structural strength of conventional Schedule 40 plastic DWV pipe.

6. The course of action that we recommend to the PRO committee is as follows. The first step is to consult more closely with the PPFA to determine what efforts they have made and what success they have had in making inroads at the level of local code writers and enforcers and local mechanical engineers. The second step is to consult with the various manufacturers of those technologies (e.g., fire-stopping devices, coatings and wraps) for the fire protection of plastic pipe. The PRO Committee should determine if these companies could use the support and financial resources of the PRO Committee, PPFA et al. to promote their product lines. Then once a menu of cost-effective plastic pipe systems has been developed and tested/approved by the relevant standard-setting organizations (e.g., ASTM, NFPA, UL) to 1-4 hour fire ratings, the PRO Committee (on its own or through a new coordinating group) must be willing to finance and otherwise support programs to educate the mechanical engineering firms

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in the "new" economics of plastics versus cast iron DWV pipe in high-rise buildings. We envisage the PRO Committee and other plastic pipe advocacy groups conducting seminars in selected regions of the country, attended by leading mechanical engineering firm personnel, letting them know that new fire-protected plastic DWV piping systems comply with model and local codes and can deliver equivalent total performance and safety to the material alternatives (cast iron, aluminum, copper) at equivalent or superior life-cycle costs. For the local authorities, plastic pipe must be promoted as a safe and reliable enhancement of the materials/methods required to provide affordable housing for the future. For the non-residential builders, the case must be made convincingly that plastic DWV piping systems involve no compromise on the high-quality materials/methods of construction that the mechanical engineers and building owners/operators demand.

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PART I

AN OVERVIEW OF THE MARKET FOR PIPE IN HIGH-RISE BUILDING CONSTRUCTION

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THE "MODEL" BUILDING CODES

THE EVOLUTION OF MODEL BUILDING CODES

The evolution of model building codes in this country is summarized briefly in Table 1 below. In 1905 the first model building code was issued by the Board of Fire Underwriters (an association of property insurance companies) with a primary focus on reducing fire hazards. This was, in effect, the first national building code, and it continued in force with periodic revisions until 1976 when the American Insurance Association adopted the use of "model" codes.

TABLE 1

THE EVOLUTION OF MODEL BUILDING CODES

Year	Code Development
1905	First model code (National Building Code) issued by the National Board of Fire Underwriters
1927	Model building code issued by the International Conference of Building Officials (ICBO)
1946	Model building code issued by the Southern Building Code Congress International (SBCCI)
1950	Model building code issued by the Building Officials and Code Administrators (BOCA)
1973	First coordinated model building code, the One- and Two-Family Dwelling Code

From 1970 on, the states began to adopt a model building code. By the end of 1980, 7 states had adopted one of the three model building codes; by 1981, 30 states had done so. The New York State code was the only one that significantly differed from the three model building codes. Twenty-one of these 30 state codes set mandatory minimum or maximum standards for local building codes in the state; the other nine state codes were purely voluntary. Fifteen of the mandatory code states prevented local jurisdictions from making their codes more restrictive than the state code; eight others allowed no variations in the local codes without explicit state approval. Even in the voluntary code states, most local authorities have to obtain state approval for amendments to the code.

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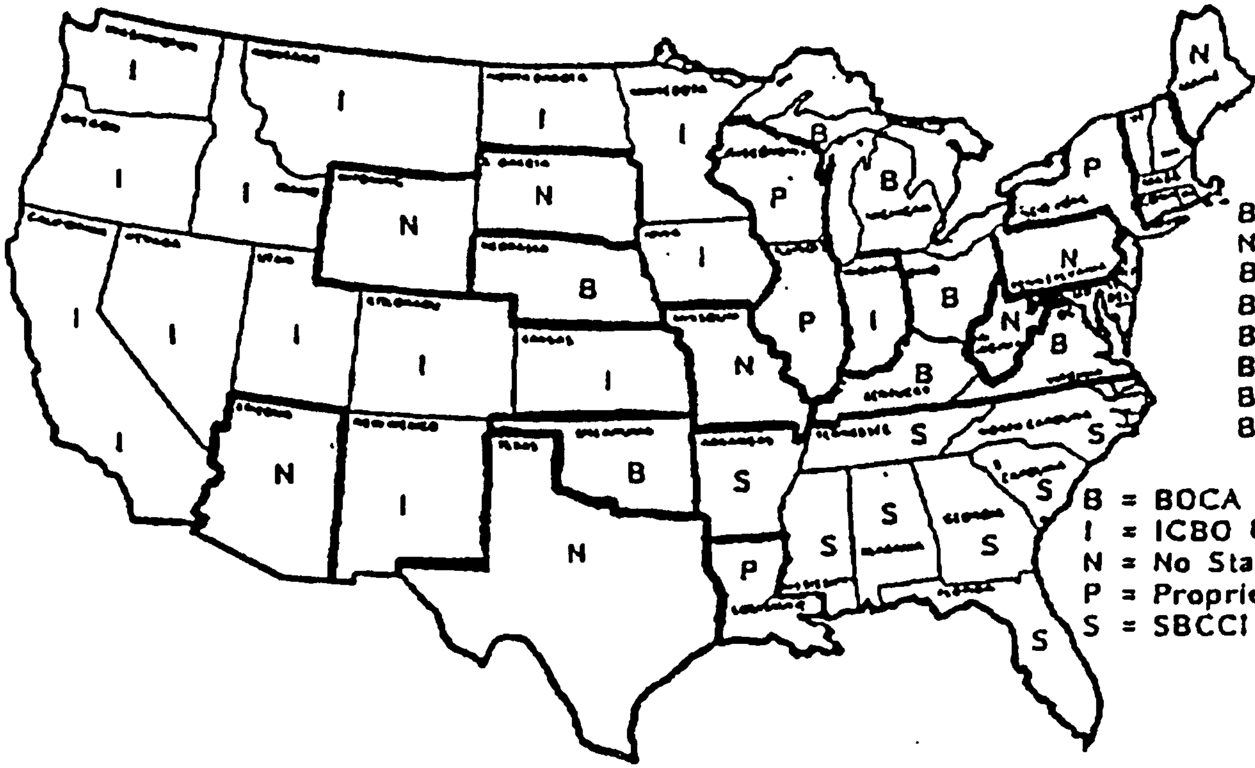
FIGURE 1

JURISDICTIONS OF THE THREE MODEL BUILDING CODES



B-Connecticut
N-Delaware
B-Maryland
B-Massachusetts
B-New Hampshire
B-New Jersey
B-Rhode Island
B-Vermont

B = BOCA National Building Code
I = ICBO Uniform Building Code
N = No State Building Code
P = Proprietary/Other Model Bldg. Cod
S = SBCCI Standard Building Code

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As a result, the three model building codes are in effect "the law of the land" despite all the attention given to the vagaries of local authorities. This is reflected in the percentage of cities adopting model codes (based on surveys conducted by different groups over the past two decades)--namely,

1964	-	47% of cities sampled had adopted one of the three model building codes					
1970	-	87%	"	"	"	"	"
1976	-	94%	"	"	"	"	"
1981	-	97%	"	"	"	"	"

INDUCEMENTS BY THE FEDERAL GOVERNMENT AND THE COURTS TO MOVE FROM LOCAL TO MODEL BUILDING CODES

Most of this pattern of local codes being superceded by national or model building codes was voluntary insofar as it removed at least one administrative responsibility from city government's mandate (and budget). However, some of this pattern was induced as the Federal Government promoted the adoption of model codes in three ways:

1) providing funds to local authorities to modernize their codes,
2) the Urban Renewal Program wherein local authorities had to adopt a model code in order to be eligible for urban renewal assistance funds, and
3) other programs (e.g., Operation Breakthrough) sponsored by the Department of Housing and Urban Development (HUD) to evaluate new building materials and techniques which favored performance standards as opposed to the specification standards typical of local codes.

It is important to be clear about the motives of the Federal Government in promoting this move to universal, performance-based standards in the building codes. The Federal Government is only minimally interested in the constant competition between traditional and new materials for building. It is more interested to preserve the role of building and construction as a key component of its demand management tool kit. When the Federal Government determines that the national economy needs a fiscal boost, additional funds to the building and construction sector offer one of the quickest pay-offs and one of the highest income multipliers. The Federal Government needs to get the approval of Congress for such additional expenditures. The last thing that the Federal Government wants to see is this Congressionally-approved boost to national and state GNP slowed

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down or shot down by idiosyncratic local building codes restricting cost-saving materials or methods in the construction of this hospital or this military base or this state university dormitory.

The courts have also taken a more active stance in hearing lawsuits that charge discrimination and/or bias in the application of local codes. The courts have encouraged the adoption of model codes as a means toward the more uniform administration of codes and greater responsiveness to new building materials and methods.

This set of insights into the recent evolution of building codes was offered to us repeatedly by the respondents to our survey--from model building code officials, local building code officials, organizations that write referenced standards in the building codes, and private sector companies (e.g., pipe manufacturers and mechanical engineers)--namely,

- The whole trend in building codes today is away from the specification standards of the past to performance-based standards.
- As a corollary of the above trend, there is a parallel move away from the tyranny of local authorities to the impersonal authority of the model codes drafted by building officials with regional, not local, responsibilities and perspectives.
- As a result, local labor unions and local suppliers of traditional building materials have been largely disenfranchised by the move from local to model codes.

THE INFLUENCE OF LOCAL CODES AND CODE ADMINISTRATORS ON THE INTRODUCTION OF NEW BUILDING MATERIALS AND METHODS

The point that we have just made regarding the relative potency or impotency of local code administrators in the approval of traditional and new materials/methods in residential and non-residential building programs in their jurisdiction is an extremely important one for our purposes. In December 1988 the Federal Trade Commission (FTC) published a report dealing with research it had conducted into "Local Building Codes and the Use of Cost-Saving Methods".[1] The research and subsequent report covered the home building market exclusively.

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[1] Federal Trade Commission, Bureau of Economics, "Local Building Codes and the Use of Cost-Saving Methods", Richard Duke, December 1988.

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The FTC prefaced their report by stating

> "It is widely believed that locally-drafted building codes significantly retard the adoption of innovative cost-saving construction methods and thereby increase the cost of housing. Builders are supposedly discouraged from using new construction methods because city officials charged with writing building codes, influenced by labor unions or material suppliers threatened by an innovation, resist approving their use. In the extreme case, the building code itself is thought to allow only a single tried-and-true method of construction."

In fact, the FTC concluded from its research (based on the period from 1981 through 1988) that this impression is both inaccurate and out-dated. First, 97% of the 162 local authorities sampled had adopted a model code. Even the four locally drafted codes had provisions very similar to a model code. Secondly, they found that builders frequently did not adopt labor-saving methods even when they were explicitly permitted by the code. Thirdly, the hypothesis that the FTC tested that a high degree of unionization would reduce the use of cost-saving methods was not borne out. They concluded that unions either do not significantly affect the use of cost-saving methods or the relationship can not be accurately measured.

The FTC did find, however, that even when the model code is adopted for use by the local authority, much is left to the discretion of the local officials (building officials and fire marshalls in particular) in the enforcement of the code. The FTC discussed the role of the local building officials as follows:

> "In many aspects of house construction, model codes allow builders discretion in the choice of building materials and methods subject to the constraint that the techniques employed must satisfy the performance standards contained in the codes. A conservative builder can follow the detailed specification guidelines contained in the code, which describes acceptable building practices down to the number and type of nails which must be used to attach the wallboard to the studs. Alternatively, builders can use any materials and construction methods they wish, as long as they demonstrate to the satisfaction of the building inspector that they are satisfying the performance criteria specified in the code. Of course, only those materials and methods that are consistent with the performance standards in the code can be employed and thus the model codes can still restrict innovation.

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"When a builder uses unconventional construction techniques, the burden of proof is on him to demonstrate that they satisfy the performance standards of the code. The building code inspector has wide discretion in accepting or rejecting the builder's plans. Some inspectors simply accept a research report from the National Association of Home Builders or a professional engineer's stamp as adequate proof that a construction design is sound. Other inspectors may set the burden of proof so high that builders do not find it cost-effective to use innovative techniques. However, if an inspector unreasonably persists in disallowing the use of novel but safe construction methods, his decisions are ultimately subject to court review and possible reversal.

"Model codes provide a compromise between the need to tailor building regulation to local conditions and the objective of having uniform building regulations so that builders need not use different construction methods when they build in different jurisdictions. The codes set forth uniform design principles by which the construction is to be evaluated, but allow the stringency of the standards to vary according to local conditions."[1]

So today few local codes exist that are characterized by restrictive, prescriptive rules related to materials. Rather, performance-based standards are the rule. And, critically, even allowing for the fact that local prejudices and local union power still obtain, the local, state and national code committe meetings held regularly to hear proposals for revising and refining these codes are open to everyone. Thus, manufacturers of new materials such as plastics, as opposed to traditional materials such as steel or cast iron or gypsum that are referred to specifically in the codes, have every opportunity to make their case and offer unbiased test results.

BEYOND THE MODEL CODES: REFERENCED STANDARDS IN THE CODES

It is also important to note that the model codes themselves do not determine performance-based standards in many critical areas. These model code organizations simply don't have the manpower and the in-house expertise to deliberate and decide on these complex issues. They instead rely on codes and standards created by other expert and

1 FTC Report, op. cit., pp. 7-9.

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independent organizations. As an indication of the range of these referenced standards in the model building codes, we refer to the BOCA National Building Code 1990 which cites standards from 43 different groups, among them

- -Aluminum Association (AA)
- -American Concrete Institute (ACI)
- -Association of Iron and Steel Engineers (AISE)
- -American Iron and Steel Institute (AISI)
- -American National Standards Institute (ANSI)
- -American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- -American Society of Mechanical Engineers (ASME)
- -American Society for Testing and Materials (ASTM)
- -Gypsum Association
- -National Institute of Standards and Technology (NIST)
- -National Fire Protection Association (NFPA)
- -Underwriters Laboratories (UL)

In Appendix B we list all 43 standards-setting organizations referred to in the BOCA building code. To this extent, there is an additional element of universality in the local building codes. It also removes the possibility of bias or ignorance at the local level restricting a fair test of a material's performance and safety features.

THE ULTIMATE ARBITERS OF MATERIAL APPROVAL: THE LOCAL CODE ENFORCERS

The ability of an existing or new material to be specified for use in an architectural blueprint or mechanical engineering design is, therefore, a function of its passing muster along a long institutional chain of command:

1) standard-setting organizations (ASTM, NEC, NFPA et al.),
2) model building/plumbing/mechanical code-writing organizations (BOCA, IAPMO, ICBO and SBCCI), and
3) local code-writing organizations, adopting all or some of these model codes.

At the end of this institutional chain there are the ultimate arbiters of material/method approval--namely,

4) the local building officials, and
5) the local fire marshalls.

If a material is prohibited from a particular application in a

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particular type of building with a particular occupancy, either

a) the material is not specified or is specifically prohibited by the standard-setting organizations and/or the model codes that reference these standards,
b) the same situation applies in the local codes, or
c) the local building official and/or the local fire marshall simply prefer it that way.

And (c) above can result from either

i) conservatism,
ii) ignorance of the code, or
iii) political pressure.

The FTC study is instructive in determining where most restrictions arise:

1) The FTC found that local codes are rarely more restrictive than the model codes on which they are based.
2) They also found that local enforcement of codes did not usually restrict builders' practices.
3) They did point "to the importance of ascertaining whether the standards embodied in the model codes represent appropriate compromises between safety requirements and costs." [1]

The FTC study continues:

> "Model codes allow builders considerable discretion to use any materials or methods of construction as long as they meet certain design criteria or pass performance tests. However, the design criteria and performance standards embodied in the codes are taken in large measure from a number of standard-setting organizations. If standard-setting organizations are too conservative in adapting their standards to new methods of construction, perhaps due to pressures from suppliers of materials currently in use, then even the model codes may be unduly restrictive. For example, plastic drain-waste-vent pipe was not approved by any model code organization until 18 years after its introduction and six years

1 FTC, op, cit., p.

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after its approval by the Federal Housing Authority. . In addition, the introduction of polyvinylchloride conduit appears to have been delayed."[1]

Thus, even though "it is widely believed that restrictive local enforcement of codes is a significant problem, at least in some localities"[2], the FTC notes that

a) "To our knowledge--no previous studies have provided systematic evidence which clearly distinguished between restrictive written codes and restrictive enforcement which goes beyond the letter of the code"[3], and

b) "our regression results did produce indirect evidence supporting the belief that as of 1981 local enforcement did not severely restrict builders' practices."[4]

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1. FTC. op. cit., p. 49.
2. FTC. op. cit., p. 48.
3. FTC. op. cit., p. 48.
4. FTC, op. cit., p. 48.

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THE U.S. BUILDING CONSTRUCTION MARKET

SOURCES OF THE DATA

There are several sources of data on building and construction activity. The best (and most widely quoted) series are those generated by the F.W. Dodge division of McGraw-Hill. As we indicated in our proposal, the high cost of a subscription to the F.W. Dodge data services precludes us from tapping directly into that source. However, we can tap into it indirectly. F.W. Dodge releases certain construction-related data on a regular basis in ENR (Engineering News Record), a McGraw-Hill publication. Secondly, the U.S. Department of Commerce subscribes to F.W. Dodge data services, and it also collects its own data from national samples. The DOC publishes construction data series in its annual Statistical Abstract of the United States.

RECENT TRENDS IN U.S. BUILDING CONSTRUCTION

In Tables 2 and 3 below we reproduce DOC data on the value of new construction put in place in current and constant (1982) dollars over the period 1965-1987. Total construction activity in current dollars grew by an average 7.7% per year--from $78.5 billion in 1965 to $398.9 billion in 1987. In constant dollars, total construction activity grew by only 1.1% per year on average.

In Figure 2 on page 22 we portray the pattern of growth in the volume (constant dollar value) of construction over this 22-year period. Interestingly, a definite cyclical pattern emerges (the venerable "building cycle"). If we isolate the "up" years and "down" years of this whole period, we derive the following pattern in U.S. building activity:

Period	Up Years	Down Years
1965-1967	-	2
1967-1969	2	-
1969-1970	-	1
1970-1973	3	-
1973-1975	-	2
1975-1978	3	-
1978-1982	-	4
1982-1987	5	-
1987-1992	-	5 (est.)

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In other words, the upside of the U.S. building cycle has generally been matched in the duration of the downside--hence, the low (1.1%) average annual growth rate in volume terms. Secondly, both sides of the cycle have tended to stretch out in recent years. On this basis, we would expect the turnaround in U.S. building and construction to take place in 1992--that is, two more years of either stagnancy or decline. And the turnaround, when it comes, may not be as strong as in the past because recent long-term demographic changes in the U.S. population are depressing the rate of household formation which translates into a lower demand for starter homes. Thus, the residential component of building activity may lag behind the eventual turnaround in the non-residential component which correlates more closely with the overall state of the economy.

TABLE 2

THE VALUE OF NEW CONSTRUCTION PUT IN PLACE, 1965-1987, IN CURRENT DOLLARS
($ million)

		Private			
Year	Total	Total	Residential Buildings	Non-Residential Buildings	Public
1965	78,474	56,554	30,235	17,995	21,920
1966	81,812	57,966	28,611	19,701	23,846
1967	83,521	58,144	28,737	18,855	25,377
1968	93,183	65,745	34,172	19,402	27,437
1969	100,464	72,671	37,214	22,530	27,793
1970	101,281	73,374	35,863	22,770	27,908
1971	117,904	88,205	48,514	23,872	29,699
1972	133,887	103,857	60,693	26,025	30,030
1973	147,368	115,020	65,085	29,949	32,348
1974	147,763	109,631	55,967	31,325	38,132
1975	144,311	102,610	51,581	27,545	41,702
1976	162,953	122,064	68,273	27,026	40,889
1977	188,048	148,607	92,004	29,693	39,441
1978	225,934	178,440	109,838	37,560	47,495
1979	252,411	200,720	116,444	49,505	51,690
1980	251,719	193,251	100,381	55,431	58,468
1981	260,160	203,611	99,241	64,695	56,549
1982	246,568	192,855	84,676	69,355	53,713
1983	281,266	227,494	125,521	65,675	53,772
1984	328,641	270,977	153,849	81,147	57,664
1985	355,735	291,665	158,474	95,317	64,070
1986	386,093	314,652	187,148	91,171	71,441
1987	398,850	323,820	194,772	91,994	75,030
AAGR (%)	7.7	8.3	8.8	7.7	5.8

Source: Department of Commerce.

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TABLE 3

THE VALUE OF NEW CONSTRUCTION PUT IN PLACE, 1965-1987, IN CONSTANT (1982) DOLLARS
($ million)

		Private			
Year	Total	Total	Residential Buildings	Non-Residential Buildings	Public
1965	276,033	198,783	107,240	63,223	77,250
1966	275,956	195,319	96,982	66,596	80,637
1967	272,964	189,976	94,372	61,929	82,968
1968	288,451	203,456	106,280	59,942	84,996
1969	291,289	210,743	108,935	64,348	80,546
1970	277,618	202,969	102,285	60,951	74,650
1971	302,795	229,096	130,477	58,786	73,699
1972	323,535	253,192	152,582	59,959	70,343
1973	327,299	257,106	148,976	63,808	70,194
1974	285,186	216,796	116,614	58,274	68,390
1975	255,670	186,284	98,542	49,037	69,387
1976	276,864	210,507	122,513	46,138	66,357
1977	295,876	235,366	148,320	47,114	60,510
1978	315,895	251,057	154,884	53,610	64,839
1979	311,973	250,349	144,450	62,877	61,624
1980	280,741	218,813	112,972	63,833	61,928
1981	268,055	211,039	102,140	67,758	57,016
1982	246,603	192,794	84,645	69,325	53,809
1983	274,106	220,729	122,098	63,234	53,377
1984	308,765	253,478	144,393	74,767	55,287
1985	324,611	266,658	145,804	85,497	57,953
1986	345,332	281,756	168,573	79,823	63,576
1987	348,995	282,951	171,310	78,183	66,044
AAGR (%)	1.1	1.6	2.2	1.0	-0.7

Source: Department of Commerce.

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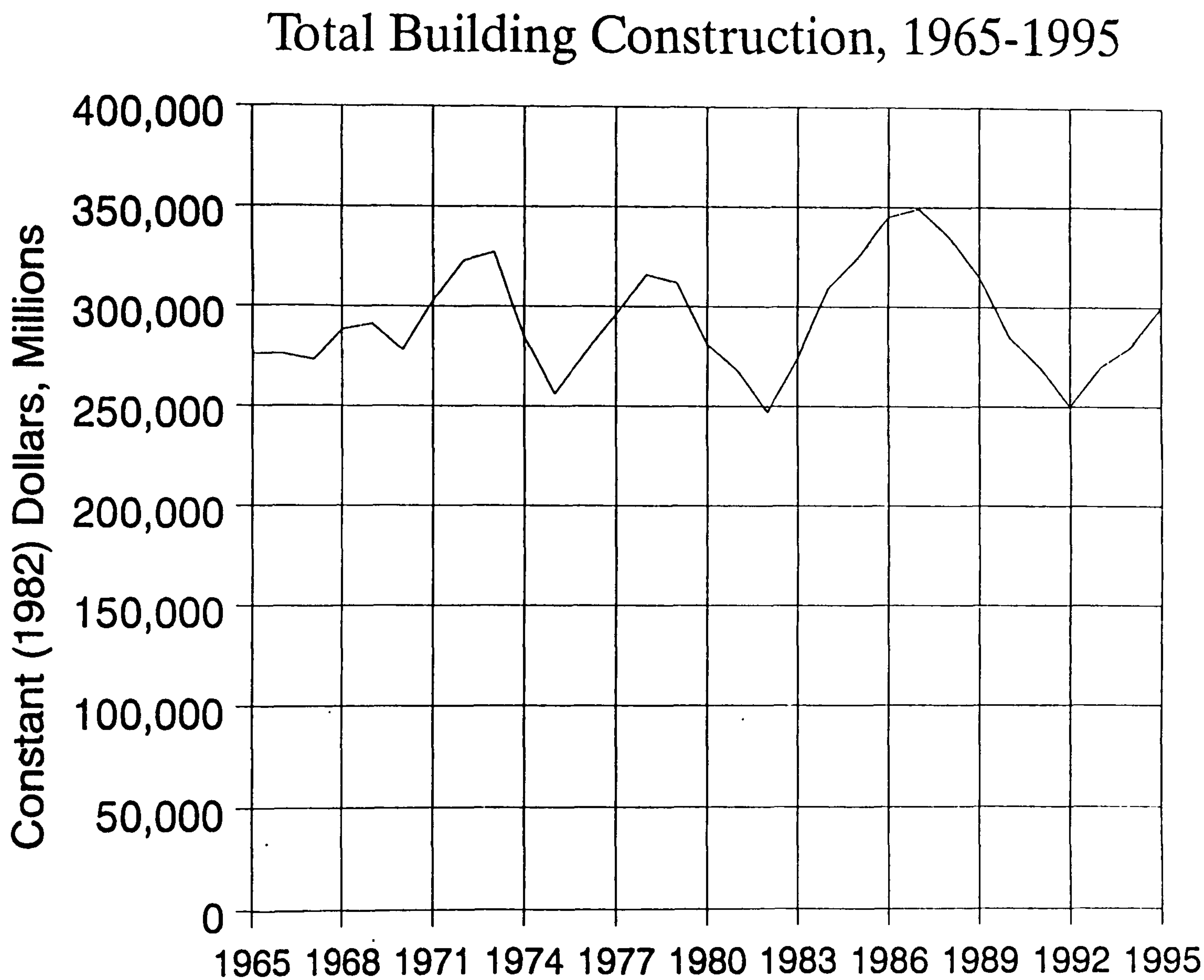
FIGURE 2



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RECENT TRENDS IN RESIDENTIAL AND NON-RESIDENTIAL BUILDING CONSTRUCTION

In Table 4 below we reproduce F.W. Dodge/DOC data on the value of construction contracts, broken down between residential and non-residential, in terms of both value (current $) and floor space (million square feet). The share of residential construction value has lately been in the range of 49.9-63.7%; in the latest year (1987) it was 57.3%. The share of residential construction in square footage terms has also been greater--57.9-69.5%; in the latest year (1987) it was 63.3%.

In Table 5 on page 25 we draw upon annual ENR data on the value of construction contracts in non-residential and multi-unit residential units from 1985 to 1990 (projected). This is an important series for our purposes in that

1) it represents the most up-to-date data, and
2) it captures almost all the construction work where the use of plastic DWV pipe is so far largely excluded.

As for the total, it has stayed fairly constant in nominal terms (thus, it has fallen in real terms) at around $118-123 million. As for the sub-total, the non-residential sector, which has grown at about 2% per year in nominal terms, accounts for 70-75% of this business. The multi-unit residential sector, which has declined more recently in nominal and real terms, accounts for the residual 25-30%.

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TABLE 4

THE VALUE AND VOLUME OF RESIDENTIAL AND NON-RESIDENTIAL CONTRACT AWARDS, 1976-1987

			Non-Residential Buildings								
Year	Total	Residential buildings	Total	Commercial[1]	Manufacturing	Educational[2]	Hospital	Public buildings	Religious	Social and recreational	Miscellaneous
Value (bil.$)											
1976	74.2	44.2	30.0	10.2	4.5	4.9	4.5	2.1	.9	1.5	1.5
1977	97.3	62.0	35.3	13.6	5.4	5.2	4.5	2.3	1.0	1.8	1.5
1978	119.9	74.9	45.0	20.6	9.2	5.7	3.8	1.5	1.2	2.1	0.9
1979	124.7	74.6	50.1	24.4	7.6	6.3	4.8	1.6	1.3	2.6	1.5
1980	116.2	63.7	52.5	24.8	8.4	6.8	5.3	1.6	1.2	2.7	1.7
1981	120.3	60.2	60.1	31.7	8.6	5.8	6.4	1.4	1.2	3.0	2.0
1982	118.7	59.2	59.5	28.2	9.5	6.1	7.8	1.9	1.2	2.8	2.0
1983	155.8	93.6	62.2	33.7	5.3	6.2	8.5	2.1	1.5	2.8	2.1
1984	175.8	101.4	74.4	42.1	7.3	7.7	7.2	2.7	1.7	3.3	2.4
1985	191.9	108.7	83.2	47.8	7.7	8.8	7.8	3.0	2.0	3.6	2.5
1986	206.7	122.9	83.8	45.8	7.3	10.5	7.9	3.2	2.1	4.2	2.8
1987	209.5	120.0	89.5	46.5	8.2	11.9	8.7	4.4	2.2	4.4	3.2
Floor Space (mil.sq.ft.)											
1976	2,819	1,867	953	440	152	118	71	42	31	45	54
1977	3,536	2,440	1,097	564	175	112	66	43	32	48	57
1978	4,101	2,815	1,286	758	219	104	53	22	35	53	42
1979	3,905	2,528	1,377	816	243	102	57	20	34	53	52
1980	3,092	1,892	1,201	688	216	95	54	18	28	50	52
1981	2,797	1,620	1,178	733	187	74	60	14	25	44	41
1982	2,442	1,497	946	571	119	74	70	19	25	38	30
1983	3,379	2,349	1,030	647	110	74	83	20	29	36	31
1984	3,635	2,396	1,238	808	147	90	70	23	29	37	34
1985	3,822	2,414	1,408	939	159	100	73	26	32	41	38
1986	3,928	2,578	1,349	869	147	116	73	30	32	43	39
1987	3,723	2,358	1,366	849	155	126	79	40	33	47	37

1 Includes non-industrial warehouses. 2 Includes science.

Source: F.W. Dodge, National Information Services Division, McGraw-Hill Information Systems Co. (NY).

TABLE 5

TRENDS IN THE VALUE OF CONSTRUCTION CONTRACTS IN NON-RESIDENTIAL AND MULTI-UNIT RESIDENTIAL BUILDINGS, 1985-1990

($ billion)

Building Category	1985	1986	1987	1988	1989	(Proj.) 1990	AAGR (%) Nominal	Real[a]
Non-residential	82.9	83.8	91.0	90.6	92.2	90.6	1.8	-0.9
Manufacturing	7.7	7.3	8.5	9.2	9.8	8.9	3.0	0.3
Commercial	47.6	45.9	47.5	46.2	46.7	42.9	-2.1	-4.7
Offices, banks	24.8	22.8	23.1	22.0	21.3	20.1	-4.1	-6.6
Stores, merchantile	13.1	13.0	13.3	13.4	12.3	12.5	-0.9	-3.5
Warehouses, garages, service stations	9.8	10.2	11.1	10.8	13.0	10.4	1.1	-1.6
Educational	8.8	10.6	11.9	12.8	14.3	15.2	11.4	8.5
Hospitals, health care	7.8	7.9	8.8	8.2	8.6	8.9	2.9	0.2
Government services	3.0	3.2	4.6	4.4	4.5	4.9	10.0	7.1
Other (leisure, rel.)	8.0	9.0	9.7	9.9	8.3	9.9	4.2	1.5
Multi-unit residential	37.0	37.2	32.4	27.9	26.4	29.1	-4.7	-7.2
Apartments	29.9	29.7	25.3	21.8	20.0	22.8	-5.3	-7.8
Hotels, motels, dorms.	7.0	7.5	7.2	6.0	6.4	6.3	-2.3	-4.9
TOTAL	119.9	121.0	123.5	118.5	118.6	119.6	0	-2.7

a Assumes annual construction cost inflator of 2.7%, based on 1985-1987 DOC statistics.

Source: Engineering News Record (ENR), F.W. Dodge Group.

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STATES WITH HIGHEST CONCENTRATION OF BUILDING ACTIVITY

F.W. Dodge supplies to ENR annual data on leading states in contract awards for

-heavy and highway construction
-building (excluding 1- and 2-family housing units)

It also supplies data on the leading states in selected residential and non-residential building categories such as

-apartments
-health facilities
-stores and shopping centers
-educational buildings
-offices and banks
-government buildings
-airport terminals
-manufacturing facilities
-amusement, religious, leisure
-garages and service stations
-nursing homes and clinics
-electric powerplants
-warehouses

In terms of the total value of building contracts, this has again stayed essentially constant over the period 1985-1989 within the range of $109.4-113.5 billion. There is also great consistency in the states that dominate this business. California is the perennial leader with roughly 15% of the total ($16-19 billion); Florida is the second most active with 7½-8% ($8-9 billion). In all, as indicated in Table 6 and Figure 3 below, 13 states account for just about two-thirds of all residential and non-residential building programs (excluding 1- and 2-family houses). And whereas construction of this type is growing fastest in Pennsylvania, Ohio, Illinois, New York and Michigan, it is falling off most severely in Texas which suffered a 50% decline in building activity over the four years from 1985 to 1989.

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TABLE 6

LEADING STATES IN THE CONSTRUCTION OF BUILDINGS,[a] 1985-1989

State	1985	1986	1987	1988	1989	Cum. % Change, 1985-1989
California	17,076	19,054	17,363	16,366	16,085	-5.8
Florida	8,996	8,816	8,312	8,082	8,392	-6.7
New York	5,671	6,095	7,941	6,524	8,127	43.3
Texas	10,071	6,907	5,356	4,415	5,038	-50.0
New Jersey	4,007	4,629	4,577	4,002	3,450	-13.9
Illinois	3,695	4,191	4,411	4,665	5,375	45.5
Virginia	3,526	4,065	4,189	4,307	3,706	5.1
Ohio	3,520	3,954	4,573	4,794	5,266	49.6
Georgia	3,316	3,577	3,391	3,439	3,531	6.5
Michigan	3,128	3,708	4,801	4,645	4,069	30.1
Pennsylvania	2,772	3,114	4,242	3,908	4,520	63.1
Massachusetts	2,746	3,172	4,173	3,910	3,114	13.4
North Carolina	3,293	2,967	2,994	3,334	3,055	-7.2
13-state Total	71,817	74,349	76,323	72,391	73,728	2.7
50-state Total	111,156	112,626	113,515	109,418	110,933	-0.2
13-state % Share	64.6	66.0	67.2	66.2	66.5	

a Excludes 1- and 2-family houses.

Source: ENR; F.W. Dodge.

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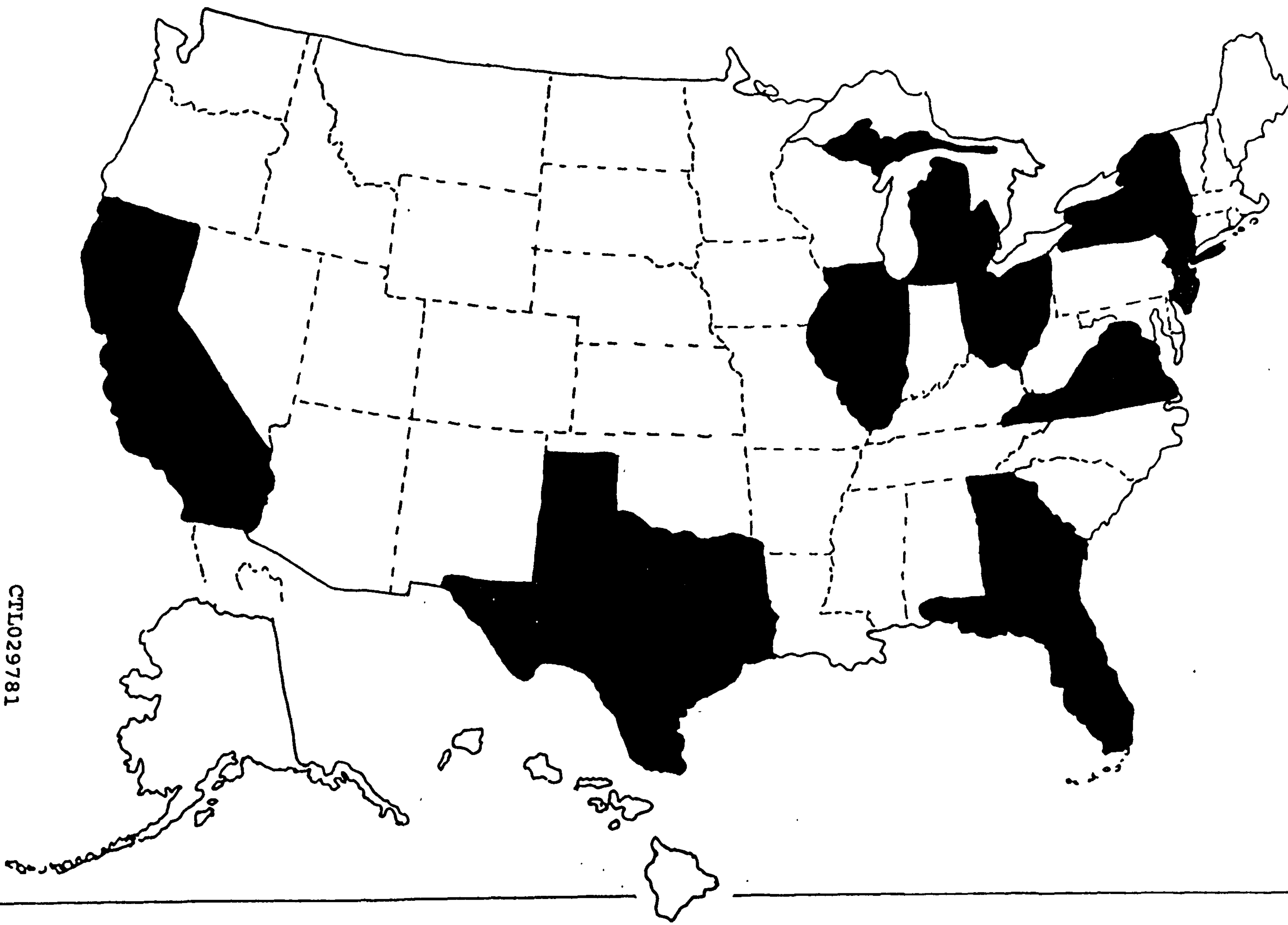
FIGURE 3

LEADING STATES IN NON-RESIDENTIAL AND MULTI-FAMILY RESIDENTIAL BUILDING CONSTRUCTION



THE DRAIN-WASTE-VENT (DWV) PIPE MARKETPLACE

MATERIALS FOR DWV OR SOIL PIPE

There are several metals and resins that compete in the drain-waste-vent (DWV) pipe business for residential and non-residential buildings. These are the pipes that carry water and water-borne wastes in a building drainage system and that vent air to and from the drainage system. The materials are as follows:

Metals

- Cast iron
- Copper
- Aluminum

Plastics

- ABS
- PVC

Copper used to have a significant foothold in the DWV pipe market---as of 1963 there were 65 million feet of copper DWV pipe produced, according to the Copper Development Association. However, in recent years, with the volatility of copper prices and the advent of plastics, mechanical engineers and building contractors have largely ceased to use copper DWV pipe except in low-volume specialty applications. The aluminum producers have always regarded DWV as a potential opportunity, and in recent years Alcan of Canada has pursued this business aggressively. Yet, there is virtually no aluminum DWV pipe installed in U.S. buildings of any type.

The principal competition is between service weight or no hub cast iron pipe on the one hand and solid wall or foam (cellular) core plastic pipe on the other. Up to recently all the solid wall plastic pipe has been extruded PVC whereas all the foam core plastic pipe was extruded ABS. Now there are new technologies available to extrude foam core PVC pipe, and this may lead to the further or even total replacement of ABS by PVC in this application set.

THE PERCEIVED ADVANTAGES AND DISADVANTAGES OF CAST IRON AND PLASTICS IN DWV PIPING SYSTEMS

Although the advantages and disadvantages of cast iron and plastics in DWV or soil pipe may be a familiar topic to the PRO Committee members, it is perhaps instructive to review these and, in particular,

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to incorporate the perceptions of people who either make the decisions or influence the materials decision-making in this application. In Table 7 below and in the accompanying text we separate out cost and performance variables in order to consider cast iron and plastics advantages and disadvantages, even though in reality cost and performance are closely related and indeed inseparable.

TABLE 7

THE PERCEIVED COST AND PERFORMANCE ADVANTAGES AND DISADVANTAGES OF CAST IRON AND PLASTICS IN DWV/SOIL PIPE SYSTEMS

	Advantage To	
Cost Parameters	Cast Iron	Plastics
Installation		
Ease of assembly		x
Light weight		x
Spacing of hangers/supports	x	
Maintenance	nd	nd
Processing of pipe and fittings		x
Raw materials	x	
Performance Parameters		
Acoustical properties	x	
Cleaning		
Resistance to mechanical & chemical cleaning agents	x	
Durability		
Corrosion resistance		x
Resistance to bacterial biological attack	nd	nd
Structural strength	x	
Electrical properties		
Grounding	x	
Flow characteristics	nd	nd
Pressure loadings		
Resistance to hydraulic loads and fluctuations	x	
Thermal properties		
Generation of smoke & toxic emissions upon burning	x	
Low coefficient of thermal expansion and contraction	x	
Resistance to high heat & flame	x	
Uniformity of pipe & fitting characteristics	x	

nd = No Difference.

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In the case of cast iron, the conventional advantages are

1) structural strength is high and this changes very little over a whole range of environmental conditions, barring extremely corrosive environments,
2) there is virtually no movement of these rigid pipes due either to hydraulic loads or thermal effects (i.e., low coefficient of expansion/contraction), barring seismic dislocations,
3) the heavy mass of cast iron (which is a disadvantage from an installation cost standpoint) insulates against noise that can be generated in multi-story piping systems,
4) cast iron pipe can be cleaned regularly, using either mechanical means (e.g., augurs and wire snakes) or chemicals, and
5) cast iron soil pipe alternates with copper hot/cold water distribution pipes as a means to ground electrical circuits and/or appliances.

The only "pure" performance disadvantage of cast iron soil pipe versus plastics DWV pipe noted in Table 7 above is corrosion resistance, and this is misleading to some extent. Corrosion affects all metal piping over time to some extent--either along the pipe lengths or, more typically, at the joints. (The latter problem is often ameliorated, under the pressure of code compliance, by using stainless steel coupling devices.) Below ground, cast iron soil pipe is subject to galvanic corrosion that can be created by strong electrical currents which set up a positive-to-negative electrical field around the metal and initiate corrosion (e.g., pitting). The presence of acids in the soil can also induce the same destructive response. So cast iron (untreated) pipe is at a disadvantage in below-ground applications. Above ground, however, the presence of moisture and acids is much less threatening to cast iron pipe. The only common environmental factor that seriously deteriorates the aesthetics and functional integrity of unprotected cast iron pipe is salt spray in coastal states. Even here, however, there are mitigating factors:

1) the presence of salt spray is diminished inside these buildings, and
2) cast iron pipe located both inside and outside coast-side buildings can be coated for corrosion resistance.

Thus, in the main, despite the influence of corrosion on metal pipes from the very point of production until the point of replace-

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ment, the mechanical engineers and the plumbing contractors always assume that cast iron pipe will outlive the original life of the building. And that means 30-50 years.

Set against this cost/performance profile of cast iron soil pipe, what are the perceived advantages of plastic (ABS and PVC) DWV (Schedule 40) pipe and pipe fittings that permit them to challenge cast iron in the high-rise segment of the business?

A cursory glance at Table 7 indicates clearly that plastic DWV pipe lives or dies in terms of superior economics of production, installation and maintenance. Yet, here again, we must qualify the impression of superior costs of plastic pipe. The cost of the raw materials required to deliver the strength and wall thickness of pipe and pipe fittings sufficient to comply with plumbing code requirements are generally recognized to be lower in cast iron, which is effectively a by-product today of the steel production process. Plastics overcome this raw material cost disadvantage on the processing side where the cost efficiencies of continuous production (extrusion) and high volume injection molding are captured. It is in the area of installation costs where the balance of total cost advantages hangs and where institutional forces work today to the disadvantage of plastics.

Plastic pipe and pipe fittings are obviously lighter and easier to assemble with solvent welding. However, the less rigid plastic pipe lengths require more frequent vertical and horizontal supports and hangers (every 2-4 feet for plastic pipe, as opposed to every 5-10 feet for cast iron pipe). And, critically, union work rules across the country require the same size plumbing crew (e.g., 1 plumber and 1 plumber's apprentice) regardless of piping materials. This serves to reduce or arguably eliminate the advantage of the lighter weight plastic pipe and fittings because the output per day of plumbers installing plastic, as opposed to cast iron, pipe may be insignificant. (Refer to pages 33-37 of this report where we cover the R.S. Means plumbing cost estimates and where we cite the Mean assumption of identical crew size for plastics or cast iron DWV pipe.)

Thus, in the extreme, even if the plastic pipe manufacturers can overcome the conservatism of code administrators, mechanical engineers et al. regarding the putative performance deficiencies of plastics in high-rise building sanitary drain piping, the total cost advantages that should accrue to plastic pipe end-users may be lost unless plumber work rules can be changed. And this has historically been a difficult task for "outsiders" to accomplish.

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Of course, the key to plastics penetrating cast iron soil pipe applications in high-rise buildings hinges more on one performance feature--flammability and toxicity--than putative arguments of superior economics. And here we quote from what appears to be a balanced observor of this business--namely, Jerome Mueller who wrote a book in 1987 for McGraw-Hill on the subject of plumbing materials and methods:

> "However, hanger spacing is not the major area of concern to code officials and fire protection officials who are both becoming sensitive to the fire characteristics of all kinds of plastic materials used in modern building construction. Basically, all plastics used in plastic piping will burn, including the flame-retardant materials and those which cease to burn when the initiating flame is removed. And, when they burn, all plastic materials release toxic and nontoxic gases. The nontoxic gases are carbon dioxide and water vapor. The toxic gases are carbon monoxide, hydrogen chloride, and hydrogen cycanide. In addition, most burning plastics release large quantities of dense smoke. Other chemical products created by the burning of plastics include small quantities of aldehydes and ketones as well as other minor chemical compounds. Of all of these, the most dangerous has been proven to be carbon monoxide which represents by far the majority of the fire load. In fairness to the plastic pipe industry the fact remains that the greatest danger from plastic materials does not come from the relatively small quantity of plastic piping, but rather from the large quantity of plastic materials contained in the spaces in which the fire occurs. Thus, the real danger is primarily from the room contents and not the piping system."[1]

THE ECONOMICS OF PLASTIC VERSUS CAST IRON DWV PIPE

An obvious part of the strategy for convincing private and public sector mechanical engineers to specify plastic DWV pipe in high-rise buildings is providing evidence or at least estimates of the superior cost burden of plastics. We encountered no one in our survey of 50+ respondents who made the case that cast iron pipe is cheaper to install than ABS or PVC. However, we found no consensus out there as to the typical extent of the cost savings of plastic DWV pipe.

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1. Jerome Mueller, Plumbing Design and Installation Details, New York City: McGraw-Hill, 1987, p. 15.

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One of the best routes to determining the actual costs of plastic and cast iron DWV pipe is to go to the data that the mechanical engineers themselves use--namely, the cost estimating services. The R.S. Means Company of Kingston, MA is one of the leaders in this field, and it publishes several construction cost data books, including the 1990 edition of the Means Plumbing Cost Data book. It covers piping, fixtures and fire protection devices. I called Means and spoke with Mel Mossman who, along with John Moyland, prepares the Means Plumbing Cost Data each year.

I worked along with Mossman to develop a simple, "typical" DWV piping section--in this case

-a 30 ft. length of pipe for horizontal drainage,
-a ¼ (90°) bend at one end of the line,
-a sanitary tee at the other end of the line,
-hangers for attachment to the sub-floor.

Although the Means data provide cost figures on single hub with lead and oakum joints, Mossman indicated that this construction is seldom used today. Rather, the mechanical engineers today design in either single hub pipe with push-on gasket joints or no hub pipe with one of three types of couplings:

1) standard (CISPI) couplings,
2) cast iron clamps with neoprene gaskets, or
3) stainless steel couplings.

The costs of these three coupling systems rise going from option (1) to (3), and in Massachusetts, according to Mossman, the building inspectors generally prefer stainless steel couplings for their superior corrosion resistance.

In Table 8 below we have brought together the individual units and their respective costs for the plastic (ABS and PVC) and cast iron pipe and fittings required to suit the plumbing configuration that we devised. Then in Table 9 following we have aggregated these costs to determine the total system (configuration) cost.

One can see that the cost of the cast iron single hub pipe lengths is slightly lower than the plastic pipe alternatives whereas the cost of the no hub pipe is slightly higher. The extra costs of cast iron piping comes in the fittings and, more specifically, in the labor required to install these fittings. Note that the cost of the couplings for the cast iron pipe include labor (assembly costs) whereas the costs of the cast iron ¼ bend and sanitary tee fittings

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do not. In effect, Mossman has incorporated almost all the cast iron piping labor costs in the coupling unit costs. In the case of the plastic fittings the labor costs are embodied in the fitting costs, and Mossman admitted that these labor costs may be overstated. In other words, whereas it is difficult to imagine a crew of less than 2 (1 plumber and 1 plumber apprentice) installing a cast iron piping system, it is plausible to imagine one plumber installing a plastic piping system.

The cost of the PVC piping system portrayed here is 0-7.3% lower than that of the cast iron piping options whereas the cost of the ABS piping system is 1.7-8.9% lower. Mossman suggested that these relativities seemed right to him insofar as he has always heard that plastic DWV piping is of the order of 5% less expensive than cast iron soil pipe. Yet, just as the Means Plumbing Cost Data points out in detail, these cost differentials can vary widely by region and by volume of construction work, along with other mitigating circumstances.

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TABLE 8

COSTS OF COMPONENTS FOR A TYPICAL DWV PLUMBING INSTALLATION IN CAST IRON AND PLASTICS

	Crew	Daily Output	Man-Hours	Cost: Materials	Cost: Labor	Cost: Total	Cost: Total (incl. O&P)
Cast Iron Components							
Pipe							
Single hub (push-on gaskets)	Q-1	57	.281	4.28	6.25	10.53	13.95
No hub (couplings)	Q-1	58	.276	5.07	6.15	11.22	14.70
Fittings							
Single hub							
¼ bend	Q-1	15	1.070	11.05	24	35.05	47
Sanitary tee	Q-1	9	1.780	16	40	56	76
No hub							
¼ bend				5.35		5.35	5.90
Sanitary tee				7.10		7.10	7.80
Couplings							
Standard	Q-1	33	.485	3.09	10.80	13.89	19.40
Gasket	Q-1	33	.485	9	10.80	19.80	26
Stainless	Q-1	33	.485	9.75	10.80	20.55	27
Plastic Piping Components							
Pipe (Schedule 40)							
PVC	Q-1	48	.333	3.20	7.40	10.60	14.50
ABS	Q-1	48	.333	3.22	7.40	10.62	14.55
Fittings							
¼ bend							
PVC	Q-1	14	1.140	7.25	25	32.25	46
ABS	Q-1	14	1.140	3.20	25	28.20	41
Sanitary tee							
PVC	Q-1	9	1.780	11	40	51	71
ABS	Q-1	9	1.780	5.50	40	45.50	65
Couplings							
PVC	Q-1	17	.941	3.30	21	24.30	35

Notes to table: See following page.

Sources: R.S. Means, Means Plumbing Cost Data 1990.
Cast iron - pp. 61-67; plastics - pp. 79-91.

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Notes to Table 8:

Crew - R.S. Means estimates the crew size required to install every pipe, pipe fitting and other plumbing fixture. In the case of all 4" cast iron and plastic pipe lengths and pipe fittings, Means assumes a Q-1 crew which is 1 plumber and 1 plumber apprentice, 16 man-hours per day.

Daily output - Units that a Q-1 crew will install in an 8-hour day.

Man-hours - Man-hours required to install one unit of work.

Material cost - Cost per linear foot of pipe and per unit of pipe fittings.

Labor cost - Labor cost incurred installing one unit of work.

Total cost - Material plus labor cost.

Total (including O & P) - Total cost including overhead and profit.

TABLE 9

AGGREGATE COSTS OF A TYPICAL DWV PLUMBING SYSTEM IN CAST IRON AND PLASTICS ($)

System Component	Cast Iron Single Hub	Cast Iron No Hub	Plastic PVC	Plastic ABS
Pipe (30 ft.)	418.50	441.00	435.00	436.50
Pipe fittings				
¼ bend	47.00	5.90	46.00	41.00
Sanitary tee	76.00	7.80	71.00	65.00
Couplings[a]	38.80-54.00	97.00-135.00	-	-
Total	$580.30-595.00	$551.70-589.70	$552.00	$542.50

a Two couplings required for single hub, five for no hub.

Source: R.S. Means Company.

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THE POTENTIAL FOR PLASTICS IN HIGH-RISE BUILDING DWV/SOIL PIPE APPLICATIONS

In Table 10 below we reproduce data from the SPI on the consumption of plastics (ABS and PVC) in DWV pipe over the period from 1984 to 1989. (This series starts with 1984 because that is the first year when DWV pipe appeared as a separate category for ABS.) We also reproduce 1984-1987 data from our 1988 BCC report on "The Competitive Pipe Industry" for the consumption of cast iron in soil pipe, and we consulted with officials at the Cast Iron Pipe Institute (CISPI) for the 1988 and 1989 figures.

We can see from Table 10 that the consumption of plastics has only grown marginally (1% per year on average) in DWV pipe over the past five years whereas the consumption of cast iron in soil pipe has fallen by 1.6% on average. In each case (as expected) the fall-off in pipe sales occurred after 1987, the latest peak in the building cycle.

We then converted these data by weight to volumetric data (linear feet of pipe). The conversion factors used were as follows:

ABS - 1.25 lbs./ft. for 4" diameter pipe
PVC - 2.0 lbs./ft. for 4" diameter pipe
cast iron - 7.4 lbs./ft. for 4" diameter pipe

Using these weight data and conversion factors, we calculate that plastics have held a steady 77-80% share of the DWV/soil pipe business over the past five years. As we will be discussing in detail for the remainder of this report, one of the principal constraints on plastics capturing <u>all</u> of this business is the reluctance of mechanical engineers to design in plastic piping (of all sorts) into high-rise buildings (that is, buildings of 3 stories or more).

This plastic DWV pipe market share estimate of 77-80% is quite plausible since, reverting back to the data in Table 4 earlier, the volume (square footage) of residential buildings is generally 63-66% of the total square footage built each year. If plastic DWV pipe is almost universally used in 1- and 2-story residential buildings, as well as in some low-rise non-residential buildings and even a very minor share of high-rise buildings, it stands to reason that the plastics share of the total DWV/soil pipe business is of the order of 75-80% in linear feet terms.

Now if, in theory, plastics could replace cast iron completely in the DWV/soil pipe segment, that would lead to a further 100 million feet of pipe produced. And at $85/100 ft. of 4" plastic DWV pipe, that would lead to a further $85 million of business. When one includes plastic pipe fittings as well, the total additional plastic pipe and pipe fittings business would be over $100 million.

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TABLE 10
THE CONSUMPTION OF PLASTICS (PVC AND ABS) AND
METAL (CAST IRON) IN DWV PIPE, 1984-1989

Volume (million lbs.)							
Plastics	1984	1985	1986	1987	1988	1989	AAGR (%), 1984-1989
ABS	150	125	125	125	119	125	-3.6
PVC	440	480	536	595	580	496	2.4
Sub-total	590	605	661	720	699	621	1.0
Cast iron	768	764	823	875	720	710	-1.6
TOTAL	1,358	1,369	1,484	1,595	1,419	1,331	-0.4
Market share (%)							
Plastics	43	44	45	45	49	47	
Cast iron	57	56	55	55	51	53	
Volume (million feet)							
Plastics							
ABS	120	100	100	100	95	100	-3.6
PVC	220	240	268	298	290	248	2.4
Sub-total	340	340	368	398	385	348	0.5
Cast iron	104	103	111	118	97	96	-1.6
TOTAL	444	443	479	516	482	444	0
Market share (%)							
Plastics	77	77	77	77	80	78	
Cast iron	23	23	23	23	20	22	

Sources: Plastics - Society of the Plastics Industry (SPI).
Cast iron - Cast Iron Soil Pipe Institute (CISPI).

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In order to isolate that portion of the DWV/soil pipe volume and value that relates to high-rise building construction, we made the assumption that at least 5% and at most 10% of all DWV/soil pipe is consumed in high-rise buildings. These lower and upper bound estimates were derived by taking the shares of floor space in all the building construction categories listed in Table 4 earlier, applying weights based on our judgments of the extent of high-rise buildings in each category, and then aggregating to produce a weighted average. Depending on these high-rise weights, the figures we generated fell in the 5-10% range.

Thus, as of 1989 we estimate that there were 22-44 million feet of DWV/soil pipe (almost exclusively cast iron) consumed in high-rise building construction, valued at $110-220 million. If, in the extreme, all that pipe could be converted over to plastics, that would lead to a new market for plastic DWV pipe of 22-44 million feet valued at $19-37 million. When the potential for plastic DWV pipe fittings are included, the total dollar potential for plastic DWV pipe and pipe fittings in high-rise building construction must be of the order of $25-50 million.

TABLE 11

THE ACTUAL AND POTENTIAL MARKET FOR PLASTIC DWV PIPE IN HIGH-RISE BUILDINGS

	Actual		Potential	
Material	Volume (mill. ft.)	Value ($ mill.)	Volume (mill. ft.)	Value ($ mill.)
Cast iron	22-44	110-220	-	-
Plastics	neg.	neg.	22-44	19-37

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THE PLUMBING PIPE MARKETPLACE

MATERIALS FOR PLUMBING PIPE

We have already noted that in the DWV pipe market the competition is between metals (mainly cast iron with some aluminum and virtually no copper) and plastics (exclusively PVC and ABS). In the plumbing pipe business the competition is between a different set of metals and plastics--namely,

Metals
Copper
Galvanized carbon steel
Stainless steel

Plastics
PVC
CPVC
Polybutylene (PB)

Copper began to replace steel plumbing pipe in the early 1900s as it was quickly accepted as a light-weight, easy to install, and safe means of conveying potable and non-potable water within buildings of all types. By the mid-1960s copper had effectively replaced all the carbon steel in potable water piping systems and almost all in non-potable water plumbing systems. However, from the mid-1960s to the present the dominance of copper in plumbing systems was eroded by the introduction of small diameter plastic pipe and, to a minor extent, galvanized steel pipe. As a result, from 1970 to 1987 the volume of copper plumbing pipe only grew by 2.4% per year whereas the volume (floorspace) of total building construction grew by close to 4% on an average annual basis.

THE PERCEIVED ADVANTAGES AND DISADVANTAGES OF COPPER AND PLASTICS IN PLUMBING PIPE

Just as in the case of DWV/soil pipe, the long-term erosion of the share of the metal pipe standard (copper) in plumbing systems has been limited primarily to low-rise residential building activity. In non-residential and particularly in high-rise buildings of all types copper is still almost universally specified for plumbing pipe with copper or brass fittings. Although we did not interview participants in the plumbing pipe market segment as comprehensively as we did in the DWV

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pipe market segment, we can use the same cost and performance parameters as in Table 7 earlier to make the following intuitive judgments in Table 12 below.

In terms of the cost parameters of Table 12, the 1/2" and 3/4" plastic plumbing pipes are only slightly lighter than the equivalent diameter Type L copper pipes, and there is little difference in terms of ease of assembly. Plastics have the advantage over copper in both raw materials and processing costs, and these advantages are reflected in the selling prices of plastic and copper plumbing pipe that we provide later in this section (Table 13).

TABLE 12

THE PERCEIVED COST AND PERFORMANCE ADVANTAGES AND DISADVANTAGES OF COPPER AND PLASTICS IN PLUMBING PIPE SYSTEMS

	Advantage To	
Cost Parameters	Copper	Plastics
Installation		
Ease of assembly	nd	nd
Light weight		x
Spacing of hangers/supports	x	
Maintenance	nd	nd
Processing of pipe and fittings		x
Raw materials		x
Performance Parameters		
Acoustical properties	nd	nd
Cleaning		
Resistance to mechanical & chemical cleaning agents	nd	nd
Durability		
Corrosion resistance	nd	nd
Resistance to bacterial biological attack	nd	nd
Structural strength	x	
Electrical properties		
Grounding	x	
Flow characteristics	nd	nd
Pressure loadings		
Resistance to hydraulic loads and fluctuations	x	
Thermal properties		
Generation of smoke & toxic emissions upon burning	x	
Low coefficient of thermal expansion & contraction	x	
Resistance to high heat & flame	x	
Uniformity of pipe & fitting characteristics	nd	nd

nd = No Difference.

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The analysis of the performance parameters point up fewer differences between plastic and metal plumbing pipe than in the case of DWV/soil pipe. Acoustics are simply not an issue in plumbing pipe material selection nor is cleaning. Both copper and plastics of all types are resistant to corrosion, and flow characteristics are essentially similar. The critical differences occur in the areas of

1) the ability to ground electrical circuits via copper (but not plastic) plumbing pipe, and
2) the superior thermal properties of copper.

Thus, these two factors obviously outweigh the relative cost advantages of plastic plumbing pipe, leading to the virtual exclusion of plastics from fire-rated high-rise buildings. And, just as the case of DWV pipe, the natural conservatism of the mechanical engineers is reinforced by the prohibition or strict limits on combustible piping built into the model and local building codes.

THE ECONOMICS OF PLASTIC VERSUS METAL PLUMBING PIPE

Just as we noted in Table 8 above where the cost of a length of schedule 40 PVC or ABS pipe is 63-75% that of cast iron single hub or no hub soil pipe, the data in Table 13 below suggest that the linear foot cost (at source) of 1/2" PVC plumbing pipe is 80% that of copper (Type L) pipe and the 3/4" PVC plumbing pipe is 66% that of the copper equivalent. CPVC pipe sells at source for a 10% premium over PVC pipe, and polybutylene pipe in either flexible coils or straight lengths sells for a significant discount versus all the other plastic and metal plumbing pipe alternatives. At the top end of the range, stainless steel pipe sells for a huge premium over all the plastic and metal plumbing pipe alternatives.

TABLE 13

MARKET PRICES OF PLASTIC AND METAL PLUMBING PIPE, BY DIAMETER
($/ft.)

Material	1/2" Pipe	3/4" Pipe
Polybutylene	0.36	0.66
PVC	0.51	0.66
CPVC	0.56	0.73
Copper	0.64	1.00
Galvanized steel	1.10	1.30
Stainless steel	2.35	2.79

SOURCES: Polybutylene - Vanguard Plastics (McPherson, KS)
PVC and CPVC - Harvel Plastics (Easton, PA)
Copper and stainless steel - F.W. Webb (Portland, ME)
Galvanized steel - R.S. Means

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We can also refer again to the R. S. "Means Plumbing Cost Data" book to determine the current installed total cost of plumbing pipe based on the various plastics and metals used. In Table 14 below, we reproduce the total cost data from R. S. Means on 1/2" and 3/4" plumbing pipe. The polybutylene pipe is by far the least expensive at $1.17-1.70/ft., depending on pipe diameter. Copper is the next best in terms of total cost efficiency at $4.83-5.65/ft. for Type L pipe. PVC 1/2" pipe is roughly 30% more expensive to install than copper pipe and the 3/4" copper pipe is roughly 15% more expensive than copper. CPVC pipe imposes a 40% cost penalty over 1/2" copper pipe and 25-30% over 3/4" copper pipe. Finally, stainless steel imposes a total cost penalty of over 100% relative to conventional copper piping.

TABLE 14

THE COSTS OF INSTALLING 1/2" AND 3/4" PLUMBING PIPE, BY MATERIAL, ACCORDING TO "MEANS PLUMBING COST DATA" (1990)

Material	1/2" Pipe	3/4" Pipe
PB		
(SDR 11, 100 psi)		
(flexible)	1.17	1.70
Copper		
(Type L)	4.83	5.65
(Type K)	5.15	6.45
Galvanized steel		
(schedule 40)	5.85	6.25
(schedule 80)	6.90	7.40
PVC		
(schedule 40)	6.15	6.55
(schedule 80)	6.70	7.20
(schedule 120)	6.85	7.35
CPVC		
(schedule 40)	6.85	7.40
(schedule 80)	7.25	7.95
Stainless steel		
(schedule 40, Type 304)	10.20	11.30
(schedule 80, Type 304)	11.45	13.45

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To understand why R. S. Means can point to lower total costs for copper versus PVC or CPVC plumbing pipe systems, we have to scrutinize the detailed breakdown of cost components. In Table 15 we isolate these cost components for selected 1/2" plumbing pipe materials. It is immediately evident that the key differential over all these materials is in the estimated daily output of pipes laid. Whereas polybutylene pipe can be installed at a high rate of 294 ft./day by 1 plumber, the rate for copper pipe is 82 ft./day and that for PVC and CPVC is less at 54 ft./day. The rate for stainless steel is lowest of all at 52 ft./day and, combined with the high raw material cost of this plumbing pipe option, that leads to the very high total cost estimates.

TABLE 15

THE BREAKDOWN OF COSTS OF INSTALLATION OF 1/2" PLUMBING PIPE BY MATERIAL

Material	Daily output (ft.)	\$/ft. of pipe installed: Material	Labor	Total	Total plus O & P
PB (flexible)	294	0.16	0.67	0.83	1.17
Copper (L)	81	1.10	2.44	3.54	4.83
Galvanized steel (40)	63	1.10	3.14	4.24	5.85
PVC (40)	54	0.66	3.66	4.32	6.15
CPVC (40)	54	1.27	3.66	4.93	6.85
SS (40)	52	4.16	3.80	7.96	10.20

If the cost relativities by material estimated by R. S. Means are in fact accurate reflections of the conditions obtaining in the plumbing pipe market, then there is little scope for PVC and CPVC replacing copper in these applications. However, to suggest (as the data in Table 15 above do) that plastics are the more expensive medium for plumbing pipe just doesn't seem to hold water. We have already suggested (see page 48) that the R. S. Means labor costs for plastic DWV pipe may be overstated. We also feel that this may be the case in the area of plumbing pipe since there is no reason why plastic pipe can't be solvent welded as fast as or faster than sweating copper pipe. This is another possible misperception in the pipe marketplace that the plastic pipe industry should carefully address in order to mount a credible challenge to metal pipe in high-rise buildings.

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THE POTENTIAL FOR PLASTICS IN HIGH-RISE BUILDING PLUMBING PIPE APPLICATIONS

In Table 16 we reproduce data from the Copper Development Association on the consumption of copper in plumbing pipe (or, in their terms, tube) over the period 1980-1989. As of 1989 there were 529 million pounds or 1.15 billion feet of copper pipe in plumbing applications. According to a spokesman for the CDA, that represents about 93% of what they refer to as water distribution piping; plastics hold a 4% share and galvanized steel a 3% share. They regard the share of stainless steel in these applications to be effectively zero.

The next step that we take in Table 16 is to isolate that share of copper plumbing pipe that is used inside the building (i.e., meter to faucet) as opposed to outside the building (i.e., main to meter). In our earlier BCC research program into the materials that compete in the pipe marketplace, we determined a ratio of 80/20 inside-to-outside copper plumbing pipe, and the spokesman for the CDA suggested that this ratio probably still obtains today. Thus, we use this 80% estimate to generate inside-the-building copper plumbing pipe totals in Table 16.

TABLE 16

THE CONSUMPTION OF COPPER IN PLUMBING PIPE, 1980-1989

Year	Total (mill. lbs.)	Total (mill. ft.)	Inside Buildings (mill. ft.)	Inside High-Rise Buildings (mill. ft.) Upper Bound	Lower Bound
1980	414	900	720	36	72
1981	401	872	698	35	69
1982	369	802	642	32	64
1983	447	972	778	39	78
1984	502	1091	873	44	87
1985	524	1139	948	47	95
1986	545	1185	948	47	95
1987	589	1280	1024	51	102
1988	524	1139	911	46	91
1989	529	1150	920	46	92

SOURCE: Column (1) - Copper Development Association
Other columns - BCC

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We then made the assumption that at least 5% and at most 10% of all plumbing piping is used in high-rise buildings. These lower and upper bound estimates were derived by taking the shares of floor space in all the building construction categories listed in Table 4 earlier, applying weights based on our judgments of the extent of high-rise buildings in these categories, and then aggregating to produce a weighted average. Depending on these high-rise weights, the figures we generated fell in the 5-10% range.

Thus, as of 1989 we estimate that there were 46-92 million feet of pipe (almost exclusively copper) consumed in plumbing systems in high-rise buildings construction. We also assume that this constituted virtually all the plumbing piping installed in these buildings. From our conversations with pipe suppliers (both manufacturers and distributors), there was very little stainless steel pipe used (except in hospitals) and even less plastic pipe. Thus, 46-92 million feet can be regarded as the total market potential for plastics in this application.

Now if, in theory, plastics could replace copper completely in the high-rise building plumbing applications, that would lead to further 46-92 million feet of plastic pipe demand. At roughly $0.60/lb. (i.e., some 1/2" and some 3/4" pipe, some PVC and some CPVC pipe) that would amount to a $28-55 million business. And again, as in the case of DWV pipe, when one includes the pipe fittings required for these piping systems, the total dollar potential for plastic plumbing pipe and pipe fittings in high-rise buildings must be of the order of $35-65 million. That compares with the $100 million potential that we estimated earlier for plastic DWV pipe and pipe fittings.

TABLE 17

THE ACTUAL AND POTENTIAL MARKET FOR PLASTIC PLUMBING PIPE IN HIGH-RISE BUILDINGS

	Actual		Potential	
Material	Volume (mill. ft.)	Value ($ mill.)	Volume (mill. ft.)	Value ($ mill.)
Copper	46-92	37-74	-	-
Galvanized steel	neg.	neg.	-	-
Stainless steel	neg.	neg.	-	-
Plastics	neg.	neg.	46-92	28-55

Neg. = negligible.

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PART II

AN ANALYSIS OF THE SPECIFIC CONDITIONS AFFECTING PLASTIC DWV PIPE IN HIGH-RISE BUILDING CONSTRUCTION

CTL029801

THE CAST IRON SOIL PIPE BUSINESS

REPRESENTATION IN THE PIPE APPROVAL PROCESS

CAST IRON SOIL PIPE INSTITUTE (CISPI)

I called Bill LeVan who is the executive vice president at the Cast Iron Soil Pipe Institute (CISPI) of Chattanooga, Tennessee. We discussed primarily the data on cast iron and plastic DWV pipe sales and cast iron soil pipe producers. LeVan wasn't willing to speculate on the future prespects of these two materials in this set of applications, probably because I had told him that the data/ insights that I was gathering would be presented to plastic industry interests.

LeVan cautioned me against relying too heavily on either CISPI or government data on cast iron pipe. CISPI only can account for the sales of its members, and these data are generally provided in value ($) terms with no volume breakdown by size, market segment, region, etc. The F.W. Dodge data on construction activity are also difficult to interpret in terms of DWV pipe requirements since they are generally reported in square footage terms and there is a big difference between the DWV pipe requirements in a warehouse as opposed to a hotel, each of comparable square footage. And then "a lot of the government (DOC) data are almost useless; it can be as much as 50% off line".

I already had the 1982-1987 data on cast iron DWV pipe and the 1982-1989 data on plastic DWV pipe that appears in Table 10 of this report when I called LeVan. He offered me 1988 and 1989 estimates. When I questioned the apparent steep (-18%) falloff between the 1987 and 1988 figures, he pointed to

1) the slowdown in construction activity during that time period,
2) the greater falloff in non-residential construction which biases the pipe mix towards the smaller diameter, lighter weight units used in residential construction, and
3) the conversion to lighter-weight (no hub) cast iron pipe.

LeVan claims to have examined this issue of plastics versus cast iron DWV pipe and he claims that he reported to his members a 2.8% improvement in the cast iron market share over the past few years. Generally, the feeling at CISPI is that cast iron has held its own in soil pipe and has even reversed the recent penetration of plastics to a small extent.

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LeVan and I went down the list of cast iron soil pipe producers that appears in Table 18 on page 55 of this report. He reminded me that U.S. Pipe is now out of this business, and they used to be number 3 producers of soil pipe.

LeVan and the CISPI membership are aware of the new firestopping devices that permit plastic DWV pipe to pass the building code requirements on materials penetrating fire-resistive spaces, floors and walls. He wouldn't speculate as to the effect that these devices might have on the plastics share of the multi-story residential and non-residential buildings. Yet he emphasized that ultimately, regardless of code strictures or permissiveness, it's the local building inspector who decides the fate of materials in these applications.

LeVan claims that Alcan has had (and will have) very little success in promoting aluminum DWV pipe because

1) this is a very different material for the plumbers to learn,
2) there are no aluminum fittings yet so you have to use cast iron fittings,
3) you have to insulate the aluminum from the cast iron to prevent corrosion of the aluminum,
4) the aluminum pipe requires a coating on the interior to prevent corrosion,
5) you can't scour the interior of the pipe because you'll degrade the integrity of the coating, and
6) you won't get aluminum pipe to last the life of a building (30-50 years) without expensive surface treatment. As I pointed out to LeVan, even aluminum-skinned aircraft, which are rigorously maintained to FAA standards, are generally retired after 20-23 years due to the risk of airframe failure due to metal fatigue.

LEADING MANUFACTURERS OF CAST IRON SOIL PIPE

In our 1988 BCC report on "The Competitive Pipe Industry" I listed (on pages 64-65) the names of 21 manufacturers of cast iron pipe and fittings. I contacted several of these companies as part of this research program and determined that today there are seven companies active in the sale/manufacture of gray cast iron soil (DWV) pipe as listed in Table 18 on the following page.

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TABLE 18

LEADING MANUFACTURERS OF CAST IRON SOIL PIPE

Griffin Pipe Products Company
P.O. Box 740
Lynchburg, VA 24505

Charlotte Pipe & Foundry Company
2109 Randolph Road
Charlotte, NC 28235

The American Brass & Iron Foundry
7825 San Leandri Street
Oakland, CA 94621

Universal Cast Iron Mfg. Company[a]
5404 Tweedy Place
South Gate, CA 90280

Tyler Pipe Industries
P.O. Box 2027
Tyler, TX 75710

The Eastern Foundry Company
Spring and Schaffer Streets
Boyerstown, PA 19512

Anaheim Foundry Company
800 East Orangethorpe Avenue
Anaheim, CA 92801

a Imports cast iron soil pipe from Venezuela; no domestic production.

Over the recent past there have been a lot of companies exiting this business. The most recent is U.S. Pipe and Foundry Company of Birmingham, Alabama which was acquired by Kravis, Kohlberg, Roberts of New York and then broken up for asset value sales.

American Brass and Iron

I spoke with Mike Chacon who is the Marketing Manager at American Brass and Iron of Oakland, California. He was very cooperative and offered a fairly comprehensive overview of the status of plastics competing against cast iron in the California DWV pipe market.

Interestingly, AB & I used to extrude ABS DWV pipe and sell it as a complement to its cast iron product line. However, they got out of that business about 2 years ago when the quality of the ABS material used by themselves and their competitors really deteriorated. Chacon mentions Centaur as one of these competitors which began to use regrind/recycled ABS in a foam core pipe construction. They eventually exited this business following a rash of lawsuits over failed pipe systems. The failure of plastic DWV pipe was so widely reported that AB & I decided to exit as well.

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Chacon mentioned other cast iron pipe fabricators which have attempted to diversify into plastic DWV pipe to take advantage of any possible switch from cast iron. Tyler Pipe Industries tried to market PVC pipe in California and they had "zero success". Charlotte Pipe also marketed PVC DWV pipe in California and had limited success. One other California pipe company, Anaheim Foundry, offers both cast iron and plastic DWV pipe.

The reason behind all these failed plastic DWV pipe ventures is that the residential market in California is switching back to cast iron in counties such as Los Angeles, Napa and Santa Rosa, and the non-residential market has always been very difficult to penetrate. There used to be some plastic DWV in 2-story and less buildings, but now all commercial DWV pipework is cast iron. ABS DWV is still preferred if plastic pipe is approved. The main reason is that PVC has a bad reputation for smoke emission and flammability which offsets the higher price of ABS.

Chacon mentioned that Alcan is active in the Northwest looking for approvals for its aluminum DWV pipe. They have showcased a hotel in Tennessee where aluminum DWV pipe was installed.

Chacon is not very bullish on the prospects for plastic (and particularly PVC) pipe for DWV applications, even though he admits that plastics are more cost-effective overall. He feels that California which traditionally leads the nation in environmental issue awareness will be essentially hostile to the widespread incorporation of flammable materials into the pipes of the state's homes and commercial buildings.

Anaheim Foundry

I called Anaheim Foundry Company of Anaheim, California and spoke with Joe Attala who is the Sales Administrator for the company. Anaheim manufactures both cast iron and ABS soil pipe. Even though his views would have been valuable since his product line straddles the plastics/metal divide, Attala was cordial but uncooperative. He wasn't even able to send along a catalogue setting out his product line since he claimed that a recent fire had destroyed all copies of their product literature.

Attala pointed to Charlotte Pipe as very active recently on the West Coast promoting plastic soil pipe. And Charlotte Pipe has the advantage of manufacturing plastic pipe and pipe fittings. Anaheim has to purchase its plastic pipe fittings from companies such as R&G Sloan Manufacturing Company of Sun Valley, California and Colonial Plastic Manufacturing Company of Tampa, Florida.

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Attala was very unwilling to comment on any aspect of Anaheim's soil pipe business or on the recent evolution of plastics versus cast iron in soil (DWV) pipe in California or anywhere else in his selling districts. He recommended twice that I consult with IAPMO officials, and I told him twice that I had already done that. He then indicated that he would be unwilling to share any information on company or regional sales of plastic or cast iron pipe since I might possibly pass on this information to his competitors.

Charlotte Pipe

I spoke with Alan Biggers who is a vice president at Charlotte Pipe and Foundry of Charlotte, North Carolina. He was cordial but basically uncommunicative, just answering my questions briefly and not offering any additional insights/data of his own on the plastics versus cast iron pipe business.

Charlotte is a key player in this business insofar as it is

1) #2 in the cast iron soil pipe segment of the business (after Tyler), and
2) the only manufacturer of cast iron, ABS and PVC soil pipe (Anaheim produces cast iron and ABS, not PVC).

When I asked Biggers how the market shares of plastics and cast iron have moved recently and will move in the future, Biggers claimed that there has been no real change over the past 10 years nor will there be in the near future. Plastics (both ABS and PVC) are now well accepted in 1-2 story residential construction. Cast iron is solid in non-residential, particularly of the multi-story type. And, if anything, the only change that Biggers detects is a switch back to cast iron soil pipe in the higher quality residential construction market (e.g., medium- to high-priced condominium complexes).

Biggers claims that plastics have reached the upper bound in its penetration of DWV pipe. In the residential area the noise factor is the main constraint; in the non-residential segment the fire/smoke factor dominates designers', contractors' and building inspectors' perception. When I asked Biggers whether he foresees any institutional changes (i.e., local or regional or national building or plumbing codes) enhancing or detracting from the prospects of plastics in multi-story buildings, he replied that he does not. Chicago was the last major change in the metropolitan areas, and now the materials will have to compete totally on their merits.

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Eastern Foundry

I spoke briefly with Stan Bloom who is a vice president at The Eastern Foundry Company, a division of Peerless Industries, of Boyerstown, Pennsylvania. Bloom did not have much time to discuss the questions that I had been raising with the cast iron soil pipe producers and he wasn't very informative in any event.

Bloom feels that the rate of penetration of plastics into the cast iron soil pipe business has been slowed down--from 10% (per year?) to 1% (per year?). He has been watching this process for 22 years, and he really feels that cast iron will always be specified in non-residential, fire-rated buildings. He used to think that the plastics industry would some day create a non-combustible or at least low/no smoke resin that could be extruded into pipe. He no longer thinks that this will happen in his lifetime.

I asked Bloom whether Eastern had ever contemplated diversifying into plastic pipe, and he replied, "No". I then asked him why his company sells no hub and service weight grades of cast iron pipe at virtually the same weight and exactly the same price. He couldn't/wouldn't answer that directly, but he did say that each of these grades are discounted in the field, so the prices might in fact be different. He doesn't feel that the no hub system saves that much in installation time and cost relative to the service weight grade option. But he is sure that it is preferable in overall cost/performance terms to plastics in multi-story buildings. The need for firestopping devices virtually eliminates the economic advantage of plastic pipe.

Bloom doesn't foresee any imminent changes in the building or plumbing codes that will enhance or detract from the opportunities for plastics in building activity of all sorts. However, he did mention that he was troubled to hear during a recent business trip to Atlanta that there are two high-rise buildings going up that have plastic pipe systems. He couldn't offer any details on those projects.

Griffin Pipe Products

Griffin Pipe of Downers Grove, Illinois is a division of Amsted Industries, a construction supply company based in Chicago. I spoke with two officials at the Griffin Pipe Products Company of Lynchburg, Virginia--Wayne Hinson and Jim Sales in the Sales/Marketing department. Sales turned out to be extremely knowledgeable in this field and willing to cooperate in my research since he has served for many years on committees of the Cast Iron Soil Pipe Institute (CISPI),

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and he was also instrumental years ago in managing Griffin's venture in plastic pressure and soil pipe.

Sales related that Griffin has been in cast iron pressure and soil pipe for over 50 years. He explained that the economics of soil pipe and pressure pipe are intimately related. One can take excess iron from the production of pressure pipe (which requires more exacting materials and processing modes) and make soil pipe out of this excess cast iron, both pipe and fittings. So the cast iron soil pipe is the "lowest man on the totem pole", yet it is important in keeping your pressure pipe business profitable from the standpoint of maximum utilization of materials. In the same way (Sales pointed out later) the economics of plastic pipe are driven by creating pipe from a basic position in the resin where the pipe itself may not be profitable, but the resin consumption is.

Sales and I went through the list of cast iron pipe manufacturers which either have been or currently are making plastic soil pipe as a complementary product line:

Griffin - Griffin entered the plastic pressure pipe business in the late 1950s and the plastic soil pipe business in the early 1960s because it seemed back then that plastics would eventually capture a major share of this business. They got out of it 15 years later--not because plastic soil pipe hadn't actually succeeded in capturing a high-volume share of this business, but because Griffin couldn't make any money at it. The competitors were either "small guys with $100,000 tied up in an extruder, operating out of a garage" or a large plastics processor with a resin manufacturing parent or business alliance. Either of these two types of competitors could beat Griffin on price, so they decided to exit the business.

Charlotte - Charlotte Pipe and Foundry is the most active player today among all the cast iron pipe companies in plastic soil pipe, but they probably aren't profitable either. Rather, they may be too "bull-headed" to get out of plastics and concede this business to the plastic pipe people.

Tyler - Tyler had been very active in plastic soil pipe at one time, but then they got out of it.

Anaheim - Anaheim Foundry is still selling cast iron and plastic soil pipe in California.

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TABLE 19

THE DEGREE OF DIVERSIFICATION INTO PLASTIC DWV PIPE AMONG THE LEADING CAST IRON SOIL PIPE MANUFACTURERS

Company	Plastics Connection
Anaheim Foundry	Current - ABS
American Brass & Iron	Past - now out
Charlotte	Current - ABS and PVC
Eastern	Never
Griffin	Past - now out
Tyler	Past - now out

Sales continued with his review of the current cast of cast iron soil pipe players and provided a useful synopsis of recent past and current activities. U.S. Pipe recently exited this business after Kravis, Kohlberg, Roberts of New York acquired them and then spun off the soil pipe division as unprofitable. Lynchburg Foundry used to manufacture cast iron soil pipe, but Griffin bought them out years ago. And Phoenix Pipe and Foundry, one of the longest standing members of this group, went out of business years ago.

Sales states that "we are a shrinking industry". The cast iron pipe industry has done a "fantastic job" over the years writing specifications into plumbing codes that favor/mandate the use of cast iron. However, the plastics people have been very aggressive and they've done an equally "fantastic job" promoting plastics as a low-cost alternative to cast iron. And they have been aided by the overall trend to incorporate cheaper and "flimsier" materials into buildings--pipe, sheetrock, plywood, studding wood, etc.--all in the name of creating "affordable housing". As a result, cast iron soil pipe sales have fallen off (implicitly, he meant in residential, not non-residential, construction).

Sales recommended (as did the Tyler Pipe Industries official that I contacted) that I contact Bill LeVan of the Cast Iron Soil Pipe Institute. LeVan might be willing to share data and insights into the plastics versus metal soil pipe issue. Sales indicated that he has just reviewed the proposed revisions of the CISPI Handbook wherein the following material characteristics for "satisfactory" performance of soil pipe are set out:

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1) durability and life service exceeding the expected life of the construction,
2) resistance to corrosion from fluids and gases commonly found in plumbing and drainage systems,
3) non-combustible--that is, does not contribute to a flame,
4) resistance to abrasion,
5) ability to withstand traffic and trench loads,
6) ability to withstand temperature extremes,
7) low coefficient of expansion and contraction,
8) joints which resist infiltration and exfiltration,
9) strength and rigidity, and
10) resistance to noise transmission.

Sales notes that cast iron obviously delivers on all these characteristics (otherwise they wouldn't be in the Handbook) whereas plastics delivers on only some of them. Some of these characteristics are important, and some are not. But if the total cost of purchasing, installing and maintaining plastic pipe is in fact lower than that of cast iron, then they are definitely going to compete in selected construction markets--maybe not high-rise non-residential, but certainly single- and two-story residential buildings.

Tyler Pipe Industries

I spoke with Boyd Tatum who is the manager of soil pipe sales at Tyler Pipe Industries of Tyler, Texas. He indicated that Tyler has two cast iron soil pipe manufacturing plants at

-Tyler, Texas
-Macungie, Pennsylvania

When I asked Tatum about the whole issue of plastics competing against cast iron in soil pipe, he answered by citing examples of plastic soil pipe failing in the field. He mentioned the case of plastic soil pipe failing somewhere in California after 12 years of use and another case of plastic pipe failing after 17 years at the Naval Air Station buildings in Memphis, Tennessee. This was his rationale for the aversion to plastic pipe among "quality builders and architects". He never mentioned the fact that Tyler Pipe Industries had a plastic soil pipe product line at one time and dropped out of that business.

When I asked about the probable shares of the soil pipe market held by cast iron and plastics, he professed not to know. He pointed me at first to the trade literature such as Supply House Times, but then admitted that the data I seek would probably not be found there. Then he recommended that I call Bill LeVan at the Cast Iron Soil Pipe Institute (CISPI) in Chattanooga, Tennessee.

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Universal Cast Iron

I spoke with Vince Berrey who is the Sales Manager at Universal Cast Iron Manufacturing Company of South Gate, California. They manufacture cast iron fittings, not pipe. They also have a separate division in Pasadena, California that injection molds ABS pipe fittings. The background to this plastics connection is that Universal bought out a Borg-Warner injection molding plant in the late 1950s or early 1960s. The machines were geared to running ABS and that is still the only resin that they run. Universal has never considered running PVC since

1) that would require investing in different equipment, and
2) PVC has always been more expensive than ABS.

Apropos (2), I mentioned to Berrey that this wasn't correct. PVC pipe grade sells for $0.36-0.37/lb. whereas ABS sells for $1.00-1.07/lb. He seemed to be confusing CPVC with PVC, and he agreed that I was probably correct.

Berrey claims that the six leading players in the production of cast iron soil pipe are

1) Tyler (which has over 50% of this business),
2) Charlotte,
3) Eastern,
4) American Brass & Iron,
5) Anaheim Foundry, and
6) Griffin.

Universal doesn't produce cast iron pipe, but it imports this pipe from a plant in Caracas, Venezuela, and it buys from all the above companies domestically. The import arrangements began as a short-term measure in the mid-1980s when it became very difficult to source domestic soil pipe. Today they continue to import pipe from Venezeula, but they are also by far the largest West Coast customer of these six companies.

Berrey explained that in his region (the 11 western states) plastic pipe is approved and commonly used in 1-2 story residential and non-residential buildings. There is no problem with the IAPMO building or plumbing codes in either case. Where there is a problem is in 3-story or higher buildings of any type. This limitation on plastic pipe in high-rise buildings results from a strict reading of the codes and universal conservatism on the part of the building officials. An exception may occur if a 2-story condominium complex has a subterranean garage. In that case certain building inspectors will pass

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plastic DWV pipe for the whole building and call it a 2-story building. But in the taller buildings--for example, 15 stories or higher where the hood-and-ladder units cannot even reach--there is simply no willingness to permit plastics. That may change, but "not in our lifetime".

I asked Berrey which companies are prominent in the supply of plastic soil pipe and he cited Charlotte and Anaheim which has a division called Spartan Plastics in Tustan, California. Charlotte also has a distribution center in Colorado from which it services nationwide plastic and cast iron accounts, pipe and pipe fittings. The plastics processors prominent in this business are

- -Apache Plastics of Stockton, CA
- -Colby of Santa Ana, CA
- -Gable of Orange County, CA
- -Polaris of Tracy, CA
- -a company based in Portland, OR
- -Standard of Salt Lake City, UT
- -Bristolpipe of Bristol, IN
- -Slocomb Plastic Pipe of Slocomb, AL

Berrey also pointed to Alcan which has become more active in promoting the concept of aluminum DWV pipe. He understands that IAPMO is considering a variance to its building code to permit aluminum in certain DWV pipe applications. He has heard of a case in Boise, Idaho where a contractor is attempting to use aluminum.

So, overall, Berrey feels that plastic pipe and pipe fittings will continue to penetrate the cast iron DWV pipe market, but complete replacement of cast iron is inconceivable with current codes and current building official mindsets..

CURRENT WEIGHTS AND PRICES OF CAST IRON SOIL PIPE

We asked virtually all the cast iron soil pipe producers that we contacted (along with the CISPI officials) for current weights and prices of these products. Whereas several company officials agreed to send us list weights and prices, none would discuss with us current market prices. Our sense is, however, based on consultations with the plastic DWV pipe people, that there is heavy discounting of cast iron soil pipe to the extent that 100 feet of 4" diameter no hub pipe that lists for $744 probably sells for about $500. We have used this latter figure in computing our market size estimates back in Table 10 earlier.

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TABLE 20

THE WEIGHTS AND PRICES OF THE VARIOUS CAST IRON PIPE GRADES USED FOR DWV APPLICATIONS

Weight (lbs.)

Size (inches)	Extra Heavy	Service Weight	No Hub	Difference (%)
1½	-	-	27	- / -
2	43	37	38	-12/+3
3	80	55	52	-35/-6
4	108	80	78	-28/-3
5	133	96	98	-26/+2
6	160	116	116	-28/0
8	263	194	187	-29/-4
10	391	296	287	-27/-3
12	475	362	-	- / -
15	693	584	-	- / -

Price ($)

Size (inches)	Extra Heavy	Service Weight	No Hub	Difference (%)
1½	-	-	42.50	- / -
2	58.55	41.50	41.50	-29/0
3	80.30	57.30	57.30	-29/0
4	105.50	74.40	74.40	-29/0
5	139.90	103.60	103.60	-26/0
6	158.20	128.00	128.00	-19/0
8	283.30	205.00	205.00	-28/0
10	460.95	340.00	340.00	-26/0
12	651.25	490.00	-	- / -
15	1003.30	720.00	-	- / -

Note: All these weights and prices relate to 10-ft. length pipes.

Source: The Eastern Foundry Company.

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THE PLASTIC DWV PIPE BUSINESS

As we mentioned in the introduction to this report, the aspect of this issue that we devoted least time and resources to in our consultations with market participants was the plastics side of the equation. The reason for this, again, is that we deemed it to be most cost-effective at this point to concentrate on the facts and perceptions out there at the level of

1) the code writers and enforcers,
2) the organizations that provide standards to these code groups,
3) mechanical engineers and other practitioners in the field who have to interpret these codes and specify pipe made from specific materials, and
4) the competition (i.e., the cast iron soil pipe producers).

Therefore, in this section we offer only a "skeleton" of the key plastic industry organizations and companies involved in the promotion and sale of plastic DWV pipe. We make no claim here to comprehensiveness nor do we presume to provide information/insights with which to PRO Committee membership is not already familiar.

REPRESENTATION IN THE PIPE APPROVAL PROCESS

SOCIETY OF THE PLASTICS INDUSTRY (SPI)

We did not consult with any officials of the SPI in the course of our research program. We would, however, make one general observation about the role of the SPI in the area of code-writing and standards-setting in the construction marketplace.

Throughout our research program--at both the literature review stage and in our conversations with important players in this building and construction industry--we constantly came upon the absence of representation by the plastics industry in deliberations on performance and safety standards for materials used in building components. As just one striking example, we discussed on page 16 earlier of this report the influence of referenced standards on local and model codes and code administrators. We mentioned that there are 43 independent organizations referenced in the BOCA model building code 1990. Among these 43 groups there are advocacy groups for almost every major material used in building and construction in this country--namely,

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Aluminum - The Aluminum Association

Brick - Brick Institute of America

Concrete - American Concrete Institute
Concrete and Masonry Industry Firesafety Committee
National Concrete Masonry Association
Precast/Prestressed Concrete Institute

Gypsum - Gypsum Association

Iron and steel - American Institute of Steel Construction
Association of Iron and Steel Engineers
American Iron and Steel Institute
Concrete Reinforcing Steel Institute
Metal Building Manufacturers Association
Steel Joist Institute

Rubber - Rubber Manufacturers Association

Wood - American Hardboard Association
American Institute of Timber Construction
American Plywood Association
American Wood-Preservers Association
Hardwood Plywood Manufacturers Association
National Forest Products Association
Red Cedar Shingle and Handsplit Shake Bureau
Texas Forest Service

Noticeable by its absence is any representation of the plastics industry in the BOCA model code list of referenced standards, even though there is a whole chapter (Article 20) devoted to "Plastic". The context here is light-transmitting plastics and foam plastics. There is no mention in this chapter of the option of plastic pipe as an alternative to, say, cast iron pipe.

THE PLASTICS PIPE INSTITUTE (PPI)

We did not consult with any representative of the PPI, for reasons stated above.

THE VINYL INSTITUTE (VI)

Similarly, we made no attempt to contact officials within the Vinyl Institute (the sponsors of our research), other than to consult regularly with Peter Lloyd of B.F. Goodrich.

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NATIONAL ASSOCIATION OF PLASTICS DISTRIBUTORS (NAPD)

On the recommendation of Tom Foster of Eslon, I attempted to reach Carol Wagner of the NAPD, based in Shawnee, Kansas since Foster felt that she might be conversant with the issue of plastic DWV pipe in low-rise and high-rise buildings. I spoke instead with David McCaughey who works with Wagner, and he claims that NAPD has no significant involvement in this issue. He agreed to send out literature on NAPD's product lines and recent promotional activities in plastics, including plastic pipe.

PLASTIC PIPE AND FITTINGS ASSOCIATION (PPFA)

I learned from my conversations with plastic DWV pipe manufacturers (e.g., John Minelli of Bristolpipe) that the Plastic Pipe and Fittings Association (PPFA) of Glen Ellen, Illinois is probably the most active plastics organization working to promote and get approvals for plastic pipe in fire-rated buildings. I called the PPFA in order to speak with Richard Church, the Director. As it turned out, Church wasn't available, so I spoke with Carol Asselmeier, the Assistant Director, and she was both extremely cooperative and also extremely interested in our research project.

According to Asselmeier, the PPFA over the past few years has been very active in this field of plastic pipe in fire-rated buildings. Their major thrust is working with the code-writing officials at the model, state and even local levels to get the right language into the codes to allow combustible materials such as plastics to at least compete when appropriately protected against fire. The PPFA field staff have, in fact, been successful to the extent that whereas once plastic pipe simply wasn't permitted, now there are at least clauses stating that combustible materials are to be avoided unless they are protected against fire and such assemblies are to be tested by UL, NFPA, etc.

The PPFA has published a manual, entitled "Plastic Pipe in Fire-resistive Construction". They have disseminated this manual to code officials, and they have had many requests for copies from the plastic pipe manufacturers. The manual provides design guides for plastic pipe being used in such a way as to comply with UL, NFPA, Ohio State heat release, and other tests on the fire performance of plastics.

I asked Asselmeier whether PPFA has done much work with Proset and other companies that manufacture firestopping devices specifically

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for plastic pipe. She is aware of Proset, 3M and others manufacturing such devices, but there has been no formal cooperation between the organization and these firms to date. For example, the first (1985) edition of the PPFA manual makes no mention of firestopping devices; the next edition (due out summer 1990) will have designs incorporating these devices.

Asselmeier also feels that the PPFA will have to work more closely with the NFPA. She knows that a plastic pipe will meet the 25 fire rating referred to in ASTM's E84 standard that materials in fire-rated buildings must comply with; it's the 50 smoke rating that is the real barrier to plastics. A closer relationship with NFPA might help to overcome this hurdle.

I asked Asselmeier whether PPFA has any record of instances where plastic DWV pipe has actually been successfully installed in fire-rated buildings. She replied that they have a file with such instances, but such information comes in on a random basis from the field staff or pipe manufacturers. I told her that I had heard of some Florida hotels where plastic pipe has been installed, but we don't (yet) have a complete list either.

LEADING MANUFACTURERS OF PLASTIC DWV PIPE

We attempted to contact a selection of plastic (PVC and ABS) DWV pipe fabricators. There are many more such fabricators than cast iron pipe producers, and there is far more regional dispersion of these companies across the country. So we could only contact a selection of companies that industry participants and observors recommended to our attention.

TABLE 21

LEADING MANUFACTURERS OF PLASTIC DWV PIPE

Spartan Plastics
(div. of Anaheim Foundry)
1301 Edinger
Tustan, CA 92680

Bristolpipe
(div. of Bristol Corp.)
P.O. Box 278
Bristol, IN 46507

Charlotte Pipe and Foundry Co.
2109 Randolph Road
Charlotte, NC 28235

Apache Plastics, Inc.
P.O. Box 5127
Stockton, CA 95205

Slocomb Plastic Pipe & Products, Inc.
302 Esto Highway
Slocomb, AL 36349

Eslon Thermoplastics
(div. of Sekisui America Corp.)
P.O. Box 240596
Charlotte, NC 28224

(continued)

TABLE 21 (cont'd)

Colonial Engineering 4000 Metzger Road Fort Pierce, FL 34947	LCP Plastics Raritan Plaza II Edison, NJ 08818

Bristolpipe

I tried several times to contact an official at Bristolpipe, and when I finally reached John Minelli, division manager, he recommended that I call the Plastic Pipe Fittings Associations (PPFA) in Glen Ellyn, Illinois. He did not wish to participate in our survey.

Charlotte Pipe

Charlotte Pipe is, as we indicated earlier, the #2 cast iron soil pipe producer in this country (after Tyler Pipe). They are also frequently mentioned as perhaps the largest plastic DWV pipe producer as well. We refer to our conversation with Alan Biggers of Charlotte Pipe on page 45 earlier in this report.

Colonial Engineering

I spoke with Bruce Packard in Engineering at Colonial Engineering of Fort Pierce, Florida. Colonial manufactures injection molded Schedule 40 and Schedule 80 PVC pipe fittings and operates 3 plants around the country

- -Fort Pierce, FL
- -Kalamazoo, MI
- -Santa Ana, CA

Packard confirmed the fact that plastic (both ABS and PVC) pipe and pipe fittings are selling very well in the Florida soil pipe market due to its conventional cost/performance advantages of corrosion resistance, light weight and ease of installation. When I asked him whether this good market for plastic soil pipe fittings was limited to residential construction, he replied that it extended to non-residential projects as well, and cited the Public Works Department of the city of Naples, Florida that uses plastic soil pipe and pipe fittings in many/all of its construction programs for the past few years. When I asked whether Florida was in fact an ideal environment for plastic pipe because of its corrosive salt spray and the absence of freezing weather that can cause plastic pipe contraction and subsequent failure, he admitted that it was ideal, but he also

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claims that there are other areas of the country where plastic soil pipe seems to be going well.

I asked Packard why plastic soil pipe seemed to be gaining acceptance recently in his region of the country--was it a building code relaxation phenomenon or was it a better appreciation of the superior economics of plastics? He pointed to the recent development of firestops to diminish (if not eliminate) the fire/smoke hazard of plastic pipe and pipe fittings in fire-resistive floors and walls. He cited MSP Products of Lake Worth, Florida that manufactures such a plastic pipe firestop and noted that Colonial injection molds the plastic parts on this patented product. I asked Packard to cite a leading architectural firm in Florida that I could contact to discuss the code and economic issues in the plastics versus cast iron decision-making process. He referred to G.E.E. & Jenson of Southern Florida.

Elson Thermoplastics

I spoke with Tom Foster who is Director of Sales/Marketing at Eslon Thermoplastics of Charlotte, North Carolina which is a division of Sekisui America Corporation. Eslon manufactures PVC pipe. Foster mentioned at the close of our conversation that the relationship with Sekisui has been a very valuable one as it allows Eslon the additional financial and technological resources required to develop new piping products and refine existing ones to compete in the various pipe market segments.

Foster pointed out at the outset that Eslon really doesn't compete that actively in PVC DWV (schedule 40) pipe. They produce this type of pipe in 1½" to 8" diameter. But their main business is in PVC pressure pipe, and this is schedule 80-type pipe for commercial and industrial applications. Companies such as Charlotte Pipe are very active in the residential DWV pipe business, and that's fine with Eslon.

I mentioned to Foster that the plastic DWV pipe manufacturers are largely limited at this stage to 1-2 story buildings due to code restrictions. He is aware of that, and he feels that if you are aiming for the high-rise bilding business,yyou would need the higher pressure ratings of schedule 80 pipe (320 pressure rating vs. the 220 pressure rating of schedule 40 pipe). There is more head pressure in taller buildings, and schedule 40 pipe will not perform to minimum standards there (acoustics, pressure, rigidity, etc.). That means moving up to $162/10ft. for schedule 80 4" diameter pipe versus less than $100/ft. for schedule 40 4" diameter pipe. (These are prices charged to the distributors, not contractors or plumbers.)

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Foster and I discussed the issue of the quality of schedule 40 and 80 pipe. He is aware that some plastic pipe manufacturers have run into trouble on the grounds of the quality of their products due to the introduction of either regrind or fillers. But he points out that the quality control on this product, from ASTM and NSF, is strict, and eventually anyone cheating on specifications will be caught. So, the better quality pipe manufacturers (and he includes Eslon and Charlotte in this category) are providing high-quality products, and the problem doesn't arise. He also feels that there are fewer low-quality pipe producers out there today.

Foster stresses that Eslon is not very active in DWV pipe because it is a low-priced product and it is difficult to make a profit at it. Charlotte Pipe is in a better position because they are running schedule 40 pipe all the time, so they derive maximum economics from their machines. Eslon alternates between schedule 40 and then schedule 80, PVC and then CPVC, so all the downtime is costly.

Foster then discussed foam core pipe. He is aware of both a foreign and a domestic equipment licensing company, and he expects this concept to do very well in low-rise DWV applications because it lowers the cost and solves at least some of the acoustics problem. The alternative to solving the noise problem is to load up the pipe with fillers to provide mass, but that comprises weight and structural strength properties. He notes that the foam core pipe on the market is clearly marked "Not for Pressure", so the foam core pipe may become the low-rise residential and non-residential DWV pipe of the future, leaving solid wall schedule 80 for the pressure applications.

Foster has not come across the firestopping devices that have recently been developed.

On the subject of flammability and toxicity, Foster notes that there are plenty of articles and films demonstrating the fact that PVC and most plastics will burn and give off smoke. So there is no sense disputing that. Yet he feels that in a fire situation the least potential problem will come from a burning DWV pipe. There are so many other plastic-based fixtures and furniture in the typical building that pose a far greater set of hazards to occupants in the event of a fire.

Foster recommended that we consult with officials at Charlotte Pipe, as well as the National Association of Plastics Distributors (NAPD) of Shawnee, Kansas. The NAPD is the major customer for Elson, Charlotte and the other pipe manufacturers.

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LCP

I spoke with two officials at the Greensboro, North Carolina office of LCP Chemicals & Plastics of Edison, New Jersey. Bob Watson is in Sales/Marketing, and he mentioned that he is aware of the research work that BCC is undertaking on behalf of the Vinyl Institute. He feels that the fire/building codes are the primary constraint to penetration of the DWV pipe market in high-rise buildings. He also pointed out that there is a need to educate people as to the actual characteristics of plastics generally and of plastic pipe in particular. For example, he told me that "many people don't realize that PVC will not burn unless it is held continuously to a flame". He also noted that buildings of all sorts are replete with plastic products--carpet backing, wallpaper, electrical wiring and outlets, furniture padding, etc. He then recommended that I speak with Johnny Hall, an LCP engineer who has for years participated in ASTM meetings devoted to setting plastic pipe standards.

Hall claims that there are many, many (perhaps 75) producers of plastic DWV pipe. Out of these the following companies stand out as leaders (at least in the Southeast region):

- -LCP of Greensboro, NC
- -Eslon Thermoplastics of Charlotte, NC
- -World of Plastics of Fort Pierce, FL
- -Colonial of Tampa, FL
- -Charlotte Pipe and Foundry of Charlotte, NC
- -Slocomb Pipe of Slocomb, AL

In terms of future scope for growth, the two keys are

1) reducing or eliminating the code restrictions, and
2) returning to a healthy economy where plastic and cast iron pipe manufacturers can share in this growth

I asked whether the advent of firestopping devices would enhance the prospects of plastic DWV pipe, and Hall answered that he hadn't followed that development closely.

Hall states that plastic DWV pipe sells in the Southeast for about $85-87/100 ft. He claims not to know the price of cast iron pipe.

Slocomb Plastic Pipe and Products

I spoke with Bob Gurney who is an engineer at Slocomb Plastic Pipe and Products of Slocomb, Alabama. I spent much of the time with

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Gurney discussing the competition between cellular core ABS and the traditional solid core and newer cellular core PVC pipe. Slocomb extrudes cellular core ABS pipe and its market share of plastic DWV pipe has been stagnant or declining for years. Now with the new French technology for fabricating cellular core PVC pipe, introduced into this country about 2-3 years ago, ABS pipe may disappear from the DWV pipe business. In the past the weight advantage of ABS pipe, combined with the cellular core technology (leading to a 1¼ lb./linear foot pipe versus 2 lbs./linear foot for PVC) overcame the resin price disadvantage of ABS (87-91¢/lb. or 3.2-3.5¢/cu. in. for ABS versus 36-37¢/lb. or 1.7¢/cu. in. for PVC pipe grade). The advent of PVC cellular core DWV pipe will eliminate the processing and weight advantages of ABS.

Gurney pointed to

- -Crestline
- -Bristolpipe
- -Bow
- -Charlotte Pipe

as companies that either have installed or are installing cellular core PVC pipe extrusion equipment. He also feels that the recent SPI data on PVC DWV pipe only reflect solid core pipe sales and production--that is, the cellular core PVC pipe amounts probably are not being recorded yet.

I asked Gurney where Slocomb sells its ABS DWV pipe and he answered that its markets are in the southern states with the notable exception of Florida which is a "PVC state"--that is, it has codes specifying PVC, but not ABS, DWV pipe. He doesn't see any change coming in the acceptance of plastic DWV pipe over cast iron pipe in high-rise buildings. That will take a long, drawn-out process to educate/convince the local code officials and the builders of the total cost-effectiveness of plastics. He noted that Chicago had recently relaxed its rules on plastic pipe in 1- and 2-family houses to respond to the need for affordable housing, but he doesn't see any breakthrough coming in plastic DWV pipe in high-rise buildings anywhere in the United States. He would like to see that happen in Florida because that state is "expanding like hell".

Spartan Plastics

Spartan Plastics of Tustan, California is a division of Anaheim Foundry which is one of the six leading manufacturers of cast iron

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soil pipe and one of only two such companies with both a plastic and a metal soil pipe product line. Spartan extrudes ABS pipe. I spoke with Bill Schreiber who is Vice President, Sales, at Spartan.

Schreiber indicated that ABS is the only real alternative to cast iron soil pipe in the western states insofar as PVC is prohibited in DWV in all localities with the exception of one (Clark County, Nevada). Schreiber contends that ABS pipe can only be used in residential and non-residential buildings of two stories or less. When I asked what prevented plastic DWV pipe from being used in taller buildings, he replied (and reiterated later) that there is an EPA environmental impact report (EIR) being prepared for the past two years out in California that has temporarily restricted plastic DWV pipe to the same level as in 1987. And under the draft EIR, plastics cannot be used in more than two floors of a commercial building. Schreiber noted that western builders have got around that rule in certain cases by introducing plastic DWV pipe in the top two floors of high-rise buildings, leaving the bottom floors in cast iron. That is permissible under the state building code and the EIR--that is, no more than two floors of plastic pipe.

There is also a strong prejudice against plastics among plumbers involved in high-rise buildings that have little or nothing to do with the codes. The unions are behind this to some extent, but Schreiber claims that both the mechanical engineers and the plumbers honestly believe that cast iron pipe offers the best long-term performance in these applications. The cast iron pipe companies have also refined the no hub system to reduce the total cost advantage of plastic DWV pipe.

I asked Schreiber whether he felt that the various new firestopping devices will assist plastics in penetrating the high-rise building plumbing systems in the West. He replied that he did not feel that they would introduce any new momentum to the plastic DWV pipe business. The main problem with promoting plastic DWV pipe in California and the IAPMO district in general is the litigation surrounding the failure of ABS pipe sold by a company called Centaur in the mid-1980s. Only 2-4 years after installation, the Centaur ABS pipe has begun to fail, leading to extensive building damage and to lawsuits potentially involving hundreds of millions of dollars. Centaur is now in bankruptcy, and some of its former officials have left the region. But the ABS pipe manufacturers such as Spartan have to deal with the backlash and the negative publicity generated by the plumbers and the cast iron pipe people. And these were all IAPMO-approved pipes. Centaur apparently introduced some off-spec or regrind ABS into its extrusion process, and the output wasn't in line with the ASTM A40 specifications.

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As an example of the repercussions of the Centaur debacle, Schreiber noted that just last week (June 18-22) the town council of Lancaster, California voted to ban ABS foam core pipe from its plumbing code. Spartan and other plastic pipe extruders tried to fight this measure in the courts, but they lost. Now they are working through the ABS Institute to contain the damage and raise the perceptions of ABS pipe, assuring potential end-users that there is no off-spec material in their product lines.

Schreiber concluded by saying that he doesn't expect to see any penetration of the multi-story buildings in the western states for many years to come. The barriers to further penetration are 50% code-related and 50% cost/performance-related. It will be years before the codes can be changed and the plastic pipe industry will have to spend years convincing the mechanical engineers and the building contractors of the overall cost/performance of plastic DWV pipe. After that they can challenge the water distribution pipe market.

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THE ALUMINUM DWV PIPE BUSINESS

REPRESENTATION IN THE PIPE APPROVAL PROCESS

THE ALUMINUM ASSOCIATION (AA)

We did not consult with any official of the Aluminum Association at this stage. However, based on previous research in the pipe market and some of our conversations in this research program, we do not believe that the AA has been very active in the pipe approval process. Rather, most of the "running" is made by the aluminum companies and, in particular, Alcan.

LEADING MANUFACTURERS OF ALUMINUM DWV PIPE

Alcan is the second largest aluminum manufacturer in North America, and it is the most active in the DWV pipe business. I spoke with Bill Roberts who is the DWV Pipe Product Manager at Alcan's Atlanta, Georgia facility.

Roberts went briefly over the history of aluminum DWV pipe. It was first manufactured after WWII when there was a shortage of cast iron. Alcan took scrap aircraft aluminum, alloyed it with copper, and used cast iron pipe molds to fabricate pipe. However, the high copper content led to internal corrosion problems and eventual failures, so that product/program was shelved.

In 1979 Alcan set up a new pipe division and it began to focus on DWV and other building pipe. It created a new composite pipe configuration--namely,

- -an outer layer of marine-grade aluminum alloy
- -an inner layer of 7072 alloy
- -a coal tar epoxy lining on the interior

The wall thickness of this aluminum pipe is the same as cast iron, so it can be used with cast iron fittings. Alcan doesn't make aluminum fittings for DWV pipe.

In 1985 the aluminum DWV pipe program went into higher gear, and Alcan received American (ASSE) and Canadian standards approval. ANSI has just approved the ASSE 1045 standard in April 1990, so the aluminum pipe is sold as "double-coded". As for model/state/local code approval, Roberts claims that he has a "hunting license" in 33 states, approval from BOCA, SBCCI and South Florida, and he is waiting for IAPMO approval. He points out that he comes from the

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electrical industry where NEC is the "law of the land". The plumbing industry, on the other hand, is "the most regulated business I've ever seen". He acknowledges that it will take years for aluminum DWV pipe to reach the level of code approval desired and many years more to get it specified in the field.

Roberts asserts that aluminum DWV pipe competes primarily against cast iron, not plastics. Plastics in 1½-4" DWV pipe is hard to compete against, and as a result the plastic DWV people "own" the residential building pipe business. In non-residential buildings, plastics confront flammability and toxic smoke emission problems, and, therefore, it can't compete in these fire-rated buildings. Aluminum can--it is UL-approved in that regard--and it will replace cast iron on the basis of light weight and corrosion resistance.

Roberts notes that the cast iron DWV pipe business has always been plagued by over-capacity. About 10 years ago there were 30 foundries making cast iron pipe; today (following the exit of U.S. Pipe) there are only 6. Yet one of these six--Tyler Pipe--can probably supply all the cast iron soil pipe required in the U.S. by itself. And Roberts and I noted (somewhat whimsically) that Charlotte Pipe can probably supply all DWV/soil pipe (plastics and cast iron) by itself. So Alcan is being realistic and only targeting that portion of the non-residential pipe market where it can offer distinct performance advantages over cast iron, rather than trying to undercut the price of cast iron pipe, in which scenario nobody will make a profit.

RECENT PRICING OF ALUMINUM DWV PIPE

According to Roberts, Alcan's policy is to price aluminum DWV pipe (as we noted in our 1988 pipe report) exactly at the list and market prices of cast iron soil pipe. He agreed with my figures of $750 list and $500 market prices for 100 ft. of 4" cast iron no hub pipe. He offered to send me literature on aluminum DWV pipe specifications and pricing.

CTL029826

THE INSTITUTIONS IMPACTING ON MATERIAL SPECIFICATIONS FOR DWV/SOIL PIPE

In Table 22 below we profile the "maze" that the plastic pipe manufacturers have to traverse in order to get their DWV schedule 40 pipe specs into residential and non-residential building construction programs. In the following section we highlight recent developments in many of these organizations.

TABLE 22

THE MAZE THAT PLASTIC PIPE MANUFACTURERS FACE IN PENETRATING FURTHER THE DWV PIPE BUSINESS

Plumbing Standards

BOCA National Plumbing Code (NBC)
IAPMO Uniform Plumbing Code (UPC)
SBCCI Standard Plumbing Code (SPC)

Building Standards

BOCA National Building Code (NBC)
ICBO Uniform Building Code (UBC)
SBCCI Standard Building Code (SBC)

Reference Building Materials and Methods

AISE	ASHRAE	GA
ANSI	ASTM	UL

Fire Safety Standards

National Fire Protection Association (NFPA)

Engineering Standards

American Society of Mechanical Engineers (ASME)

Engineering Practices and Perceptions

Mechanical engineers
Mechanical contractors

Cost Estimation

R.S. Means Plumbing Cost Data (and others)

Continued...

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TABLE 22 (Cont'd)

Piping Alternatives (products and services)

- Cast iron pipe manufacturers
- Plastic pipe manufacturers
- Aluminum pipe manufacturers
- Copper pipe manufacturers
- Pipe wrap and firestopping devices manufacturers

Plumbing Community

- Plumbers
- United Association of Journeymen & Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada

THE STANDARDS-SETTING ORGANIZATIONS

In Appendix B we list over 50 organizations that promulgate standards that impact on materials that can be used in building construction programs. In our research program we consulted in detail with two--namely, the American Society of Mechanical Engineers (ASME) and the National Fire Protection Association (NFPA).

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

On June 13 I went to New York City to use the library facilities at the United Engineering Center on 345 East 47th Street in Manhattan. The Center has the headquarters or supplementary offices for numerous engineering societies such as

-American Society of Mechanical Engineers (ASME)
-American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)
-American Institute of Chemical Engineers (AICHE)
-American Institute of Mining, Metallurgical and Petroleum Engineers (AIMMPE)
-United Engineering Trustees (UET)

I visited the ASME offices and spoke initially with Christine Krupinski who is an engineer with responsibility for preparing the ASME code book on pressure piping (B31). When I began to ask detailed questions on plastics in DWV piping, Krupinski directed me to Calvin (Cal) Gomez, her boss at ASME, who is the Secretary of the B31 Group. He recommended that I purchase a copy of the ASME B31.9 code book on "Building Services Piping", even though this book deals with

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pressure piping. In Gomez's view, ASME would apply the same criteria to DWV pipe as to pressure pipe. And, reflecting that opinion, it is noteworthy that there is no separate committee like B31.9 dealing with sanitary and storm drain piping on its own.

Gomez has been the secretary to the B31 committee for many years, and he is well versed in the issue of plastics competing against metals (cast iron) in the soil/DWV pipe market. Gomez shed some insights into the history of B31, saying that ASME has been involved in the publication of national codes for piping since the 1920s with the approval of ANSI (then the American Standards Association). In 1978 ANSI formally granted accreditation to ASME to continue to develop a Code for pressure piping. The first B31.9 code section was published in 1982, and the latest edition is that of 1988 with 1989 addenda.

Parenthetically, Gomez laughed when I referred to the influence of the plumbers union on the whole issue of plastics versus metals in DWV and other piping. The unions used to participate in ASME pipe standard writing programs, but they were always inflexibly opposed to even a discussion of the merits of plastics in piping of any sort, particularly DWV. Gomez claims that ASME eventually tired of these "purely political" exchanges and removed the plumbers' union representatives from the B31 deliberations.

The B31.9 code excludes "hot and cold potable water piping and sanitary and storm drainage systems". For these applications, B31 directs the engineer to local plumbing codes.

The B31 code offers a number of insights into the advantages and disadvantages of plastics in pressure pipe systems. On page 20, the code states

> "Particular care must be taken in selecting the methods given in paragraph 919.2.2 (covering means of providing flexibility in pipe systems) when laying out non-metallic piping systems, because they are difficult or impossible to analyze, have very limited capacity for overstress, are subject to brittle failure, and may have high coefficients of thermal expansion and non-linear stress-strain characteristics."

The code then provides two pages (pp. 22-23) of data on the moduli of elasticity and thermal expansion coefficients of

- -carbon steel
- -stainless steel

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-aluminum
-copper
-asbestos-cement
-plastics (ABS, CPVC, PVC, PB, PE, PP and reinforced plastics)

In Table 23 below we reproduce some of these data from Table 919.3.1 of the B31 code.

The B31.9 code also deals with loads on pipe-supporting elements (e.g., hangars). In Figure 721.1.3D (reproduced as Figure 4 below) the maximum allowable support span in feet of plastic pipe of various types is compared to that of copper and aluminum. Schedule 40 ABS and PVC (which are the types used for DWV) with a nominal pipe size of 4" requires supports every 6½ ft. whereas copper and aluminum requires such supports every 12½ ft. for the transport of water and other liquids.

Finally, in Chapter III on "Materials", the B31.9 code refers to cast iron and plastics under the heading of "Limitations on Specific Materials". It notes that "the low ductility of cast iron should be considered and its use should be avoided where shock loading may occur". As for plastics, the code makes the following comments on thermoplastic- and thermoset-based piping:

923.3.2 Thermoplastics. Thermoplastics shall not be used for toxic fluids or for oxygen. They shall not be used for flammable liquids or flammable gases above ground. If used for compressed air or other gases above ground at more than 20 psig, piping larger than NPS 2 shall be encased in shatter-resistant material.

Consideration shall be given to the brittleness and flammability of thermoplastics and to their loss of strength under only slight increases in temperature. In selecting thermoplastics, note that design properties are subject to considerable variation from one type and grade to another.

923.3.3 Reinforced Thermosetting Resin. In selecting reinforced thermosetting resin (RTR) piping, note that design properties are subject to considerable variation from one type and grade to another. Consideration shall be given to the flammability of RTR piping and its susceptibility to brittle failure.

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TABLE 23

MODULI OF ELASTICITY AND THERMAL EXPANSION COEFFICIENTS OF METALLIC AND NON-METALLIC PRESSURE PIPE

Material	Modulus of Elasticity, psix10^{-6}	Coefficient of Thermal Expansion, in./in., °F x 10^{-6}	Linear Thermal Expansion in./100 ft., Between 70°F and Indicated Temp., °F	
			50	100
Carbon steel	27.5	6.31	-0.14	0.23
Austenitic stainless steel	29.0	9.26	-0.21	0.34
Aluminum	10.0	12.65	-0.28	0.46
Gray cast iron	13.0	5.89	-0.14	0.21
Copper CA 122 (99.9 Cu)	17.0	9.50	-0.23	0.34
Copper CA 230 (red brass) (85 Cu)	17.0	10.40	-0.25	0.37
Asbestos-cement	3.0	4.5	-0.11	0.16
ABS 1208	-	60.0	-1.44	2.16
1210	0.25	55.0	-1.32	1.98
1316	0.34	40.0	-0.96	1.44
2112	-	40.0	-0.96	1.44
CPVC 4120	0.42	35.0	-0.84	1.26
PVC 1120	0.42	35.0	-0.72	1.08
1220	0.41	35.0	-0.84	1.26
2110	0.34	50.0	-1.20	1.80
2112	-	45.0	-1.08	1.62
2116	0.38	40.0	-0.96	1.44
2120	-	30.0	-0.72	1.08
PB 2110	-	72.0	-1.73	2.59
PE 1404	-	100.0	-2.40	3.60
2305	-	90.0	-2.16	3.24
2306	0.09	90.0	-1.92	2.88
3306	0.13	90.0	-1.68	2.52
3406	0.15	0.0	-1.44	2.16
PP 1110	-	48.0	-1.15	1.73
1208	-	43.0	-1.03	1.55
2105	-	40.0	-0.96	1.44
RTRP	Consult manufacturer			

Source: ASME/ANSI B31.9-1988, "Building Services Piping," 1988, p. 22.

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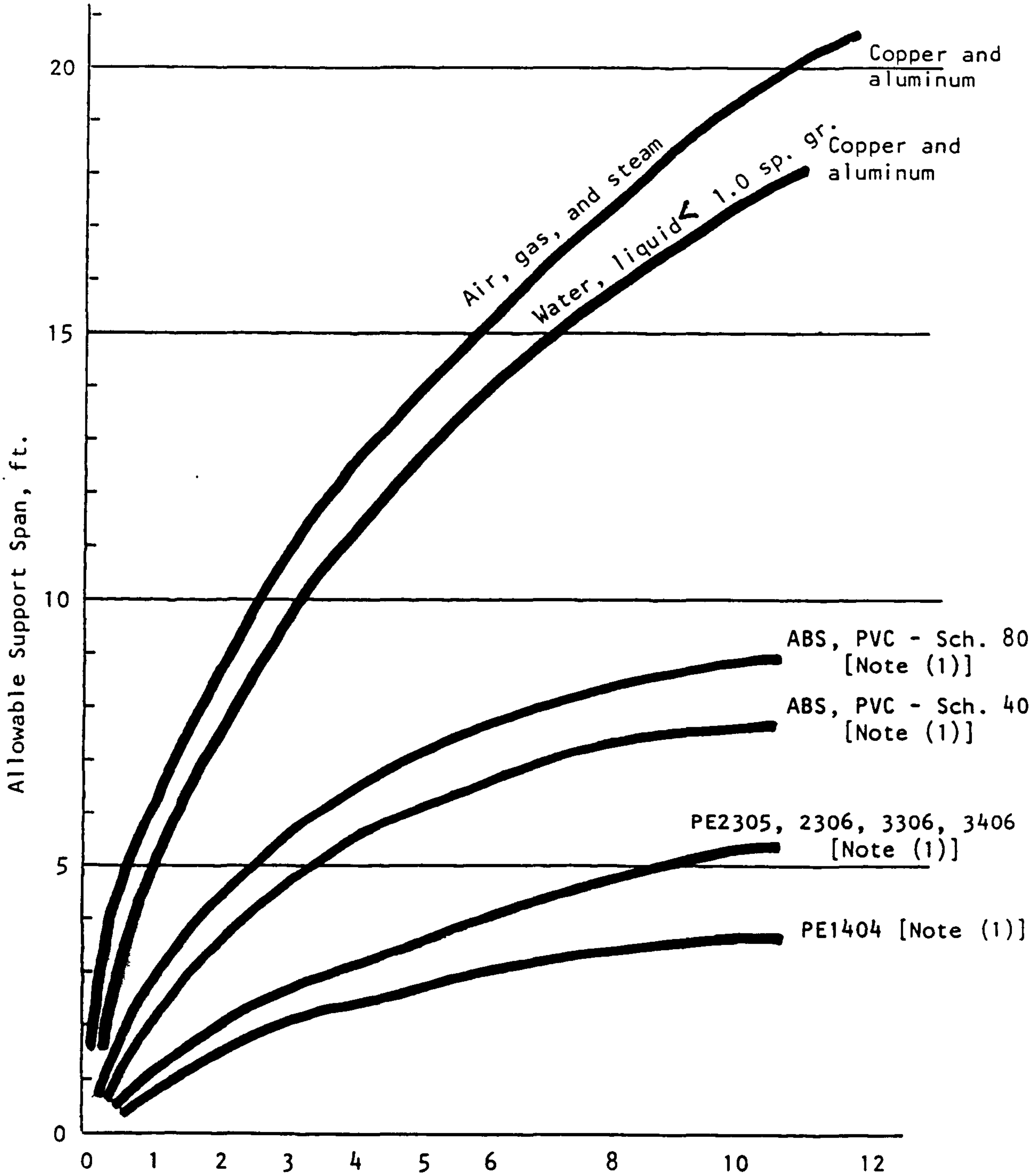
FIGURE 4

ALLOWABLE SPAN OF SUPPORTS FOR COPPER, ALUMINUM AND PLASTIC PIPE



Note: (1) Thermoplastics data are for water at 70°F maximum. Closer support spacing is required at higher temperature, continuous support at 100°F and higher.

Source: ASME/ANSI B31.9-1988.

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Gomez recommended that I consult with members of the B31 committees. One that we recommended strongly was Paul Bourquin of Wolff & Munier International of Hawthrone, New York, a major mechanical engineering firm. Bourquin was unavailable at the time I called, so I spoke with his colleague, Charles Procell, an engineer who works closely with Bourquin and who specializes in air conditioning and heating systems. He is on the TC91 committee of ASHRAE, and he is familiar with the recent activities of the B31 committee of ASME.

Procell claims that plastic pipe is seldom used in commercial buildings in New York State and never in New York City. He has used it one time in a Westchester County Marriott Hotel for the condensate drain pipe from the fan coil of an air conditioning system. Plastic pipe was permitted in that case because the hotel had fully plastered ceilings and the building was fully sprinklered. Other than that, Procell and his company would never specify plastic pipe in volume in its building designs.

The main problem with plastic pipe, according to Procell, is smoke spread and toxicity. In a high-rise building the maximum height that a fire truck ladder can reach is 65 ft. for evacuating occupants. All the floors over 65 ft. have to be sprinklered in New York State. Yet the problem of smoke spread of burning plastic pipe remains. The problem is determining the likely smoke spread of cold smoke versus hot smoke. Hot smoke (untouched by sprinkler systems) is predictable; it rises up to the ceilings and collects. Cold smoke--that is, smoke that sprinkler water reaches--behaves erratically, and some of this smoke from burning plastic pipe will drop to the floor as particulate and impact on the flooring. This complicates fire-fighting and evacuation procedures. In New York City, plastics, with a flame spread of 25 ft. and a smoke spread of 50 ft., is totally unacceptable. So Procell cannot envisage plastic pipe being approved for multi-story metropolitan area piping.

Procell is very critical of the plastics industry. He claims that he and Paul Bourquin authored the pipe characteristics by material chapters of B31.9. They went to the metals (copper and steel) companies and associations, and had no trouble getting pressure ratings by wall thickness, etc. However, they could not get such data from the plastics industry. The SPI was of no help, and the plastic pipe manufacturers just stonewalled. Finally, Procell claims, he converted from a plastic pipe protagonist to a plastic pipe antagonist and warned the plastic pipe manufacturers "unless you get us plastic pipe pressure ratings to the same degree of detail as those from the metal pipe people, I'm going to <u>fight</u> to get plastic pipe totally out of the ASHRAE and ASME code books <u>next</u> (code revision) cycle".

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Having said this, Procell acknowledges some of the reasons why the plastic pipe manufacturers won't cooperate in delivering specifications data. When you test a cast iron ingot for tension, compression, etc., you know the specs of any cast iron pipe drawn from the batch. And if there is a pipe failure, you know who to go back to. With plastics, the resin may pass muster, but if you extrude it and change the recommended processing temperature just slightly, you change the pressure ratings, wall thickness and other key performance parameters of the pipe. And when that pipe fails, no one wants to claim responsibility--that's taboo.

Procell knows that all the national building and plumbing codes are different in their treatment of plastic pipe. And he also knows that plastic pipe is used in certain parts of the country in high-rise DWV applications. However, he still contends that plastic pipe shouldn't be permitted anywhere until the pipe manufacturers can standardize and qualify their output. Plastic DWV pipe may be justifiable in Florida, but in New York State (certainly Westchester County) there is no great concern over salt spray corrosion of metallic pipes. Rather, the key issues for mechanical contractors and engineers are

1) What impact will plastic pipe have on total life-cycle installation and maintenance costs?
2) What type of building is it?
3) What type of occupancy/occupancies are there in that building?
4) What kind of fire department do we have in that district--professional or volunteer?
5) What kind of water supply system do we have to fight a possible fire in that building?

Apropos (4), Procell points out that, in general, occupants don't die in high-rise building fires; firemen do. They enter those buildings without self-containing breathing apparatus, and if they encounter toxic smoke, they can fall victim to it long before the heat of the fire is life-threatening. And that scenario is played out more often with volunteers than with professional fire-fighters.

Procell feels that about half of the current under-representation of plastic pipe in high-rise, commercial buildings is due to the codes and the other half is due to genuine concerns among the mechanical engineering community regarding the total fire safety and operational efficiency of these pipes. He doesn't expect to see a significant change in plastic pipe utilization in these buildings for many years, perhaps not within the time frame of his generation of engineers. The

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next generation might be more innovative and less risk-averse. After all, plastics are used in building and construction applications in England (e.g., air conditioning fans and fan coils) whereas they have not yet penetrated these applications in this country yet.

Procell also points to the militancy of the plumbers' union in defending the use of cast iron pipe. They are currently in the middle of a 5-year building downturn and they are engaged in a longer-term fight against plastics that threaten their union rules and livelihoods (whatever about pensions). The unions will continue to fight this challenge relentlessly.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

I spoke with Joe Jardin who is the Life Safety Engineer at the National Fire Protection Association (NFPA) in Quincy, Massachusetts. Jardin has responsibility for the NFPA's Life Safety Code which offers standards for fire protection in buildings of all types. As Jardin notes, "it's not a building code, but it's the closest that we come to a building code". It deals with fire sprinkler systems, means of egress, recommended sizes of hallways and stairways, etc.--all with the goal of providing occupants the greatest protection against fire and the best prospects for escaping a fire situation.

Jardin confirmed what I had read--that there is a definite trend to installing fire sprinkler systems in as many buildings (residential and non-residential) as possible, particularly in higher risk occupancies. NFPA Standard 113, written in the early 1980s (apparently), deals with fire sprinkler systems. It recommends that these systems be installed in all high-rise buildings and hotels/motels. In the next revision of the NFPA Standard 113 there will be a recommendation to mandate fire sprinkler systems in all health-care facilities and dormitories, regardless of the height/stories of the building. Jardin pointed out that many people in the fire protection business would like to see fire sprinkler systems installed in <u>all</u> new and retrofitted buildings, and indeed there are communities across the country (see p.118 of this report) that mandate these systems for all new 1- and 2-family houses. But Jardin recognizes that the economics of these systems have to be balanced against the fire safety enhancements to be gained. And the NFPA has, therefore, been willing to reduce the required fire ratings on walls, floors and ceilings as an inducement to install these systems.

When I asked about the implications of all this for plastic pipe, Jardin stressed several times that the NFPA doesn't get involved

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with pipe material preferences. That's a building code issue. In NFPA Stand 113 and recent amendments (113B and 113R) they refer to UL-apprc._d pipe for these sprinkler systems. If plastic pipe qualifies, fine. However, he did indicate that he would personally question the widespread use of plastic pipe in these fire sprinkler systems in view of the toxicity problems. He also doesn't feel that the proliferation of fire sprinkler systems would necessarily enhance the prospects of plastic DWV pipe in high-rise buildings, again due to the concern over toxicity. Jardin mentioned that there is a Standard Technical Committee of NFPA that addresses the toxicity of materials used in modern residential and non-residential buildings, and they report to the NFPA standards council. He couldn't cite the name of any member of that committee.

At the end of our conversation, Jardin offered the view that plastics have more of an opportunity today to qualify on their merits for any piping application insofar as all the codes (building codes and fire codes) are moving away from a specifications orientation to a performance-based standards orientation. So if plastics can deliver the total performance requirements of fire sprinkler pipes or DWV pipes or water service pipes, then that case must be made to the model and local building code officials.

MODEL CODES

A SYNOPSIS OF THE THREE MODEL PLUMBING CODES AS THEY RELATE TO MATERIALS FOR DWV PIPE IN FIRE-RESISTIVE CONSTRUCTIONS

BOCA National Plumbing Code (NPC)

The BOCA National Plumbing Code (1990) has 18 articles or sections dealing with the following issues:

Article	1	Administration and Enforcement
"	2	Definitions
"	3	General Regulations
"	4	Materials
"	5	Joints and Connections
"	6	Sanitary Drainage Systems
"	7	Indirect Waste Piping and Special Waste
"	8	Storm Drainage Systems
"	9	Vents and Venting
"	10	Traps, interceptors, Separators & Backwater Valves
"	11	Drainage Pipe Cleanouts
"	12	Plumbing Fixtures
"	13	Hangers and Supports

Continued....

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Article 14 Health Care Plumbing
" 15 Water Supply and Distribution
" 16 Individual Water Supply
" 17 Inspection, Tests and Maintenance
" 18 Engineered Plumbing Systems

The key Articles for our purposes are 1, 4, 6 and 9. The essential insights from Article 1 are as follows:

<u>P-100.2 Scope</u>

"The design and installation of plumbing systems, including sanitary and storm drainage, sanitary facilities, water supplies, storm water and sewage disposal in buildings shall comply with the requirements of this code."

<u>P-100.3 Intent</u>

"This code shall be construed liberally and justly to secure the proper installation of systems for furnishing potable water, for sanitary sewage disposal and storm drainage; and to insure public safety, health and welfare insofar as they are affected by the installation and maintenance of plumbing."

<u>P-101.2 Matters Not Provided For</u>

"Any plumbing requirement essential for the sanitary safety of an existing or proposed building or structure or essential for the safety of the occupants thereof, and which is not specifically covered by this code, shall be determined by the code official."

<u>P-108.4 Alternative Materials and Equipment</u>

"The provisions of this code are not intended to prevent the use of any material or equipment not specifically prescribed by this code, provided any such alternative has been approved. An alternative material, equipment or method of construction shall be approved when the code official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is,for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety."

<u>P-108.4.1 Research and Investigations</u>

"The code official shall require that sufficient technical data be submitted to substantiate the proposed use of any

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material or assembly, and if it is determined that the evidence submitted is satisfactory proof of performance for the use intended, the code official shall approve its use subject to requirements of this code. The costs of all tests, reports and investigations required under these provisions shall be paid by the applicant."

In Article 3 (General Regulations) the protection of pipes against

-breakage
-corrosion
-freezing

is covered, but not (interestingly) flammability or combustibility.

The materials that BOCA qualifies for above-ground and below-ground drainage and vent (DWV) pipe are set out in Table 18 below.

TABLE 24

MATERIALS PRESCRIBED BY BOCA FOR ABOVE-GROUND AND BELOW-GROUND DWV PIPE

Above-Ground

Material	Standard (see Appendix A)
Acrylonitrile butadiene styrene (ABS) plastic pipe	ASTM D2661; ASTM F628
Aluminum tubing	ASSE 1045; CAN3-B281
Brass pipe	ASTM B43
Cast iron pipe	ASTM A74; CISPI 301
Copper or copper alloy pipe	ASTM B42; ASTM B302
Copper or copper alloy tubing (Type K, L, M or DWV)	ASTM B75; ASTM B88; ASTM B251; ASTM B306
Galvanized steel pipe	ASTM A53
Lead pipe	FAWW-P-325B
Polyvinyl chloride (PVC) plastic pipe (Type DWV)	ASTM D2665; ASTM D2949; ASTM F891

Below-Ground

Material	Standard (see Appendix A)
Acrylonitrile butadiene styrene (ABS) plastic pipe	ASTM D2661; ASTM F628
Cast iron pipe	ASTM A74; CISPI 301
Copper or copper alloy tubing (Type K or L)	ASTM B75; ASTM B88; ASTM B251
Polyvinyl chloride (PVC) plastic pipe (Type DWV)	ASTM D2665; ASTM D2949; ASTM F891

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IAPMO Uniform Plumbing Code (UPC)

The IAPMO Uniform Plumbing Code (1988) has 13 chapters or sections dealing with the following issues:

Chapter	1	Definitions
"	2	Materials and Alternates
"	3	General Regulations
"	4	Drainage Systems
"	5	Vents and Venting
"	6	Indirect and Special Wastes
"	7	Traps and Interceptors
"	8	Joints and Connections
"	9	Plumbing Fixtures
"	10	Water Distribution
"	11	Building Sewers
"	12	Fuel Gas Piping
"	13	Water Heaters and Vents

In Chapter 2 (Materials and Alternates) Section 201 - Minimum Standards states that

> "--all materials, fixtures or devices used or entering into the construction of plumbing and drainage systems, or parts thereof, shall be submitted to the Administrative Authority for his approval and shall conform to approved applicable standards, or to other equivalent standards acceptable to the Administrative Authority. --Design and materials for special conditions or materials not provided for herein may be used only by special permission of the Administrative Authority after he has satisfied himself as to their adequacy."

> "--the Administrative Authority has discretionary powers to permit deviation from the provisions of this Code, provided that such a proposal to deviate is first submitted for proper determination in order that health and safety requirements, as they pertain to plumbing, shall be observed." --"The provisions of this Code are not intended to prevent the use of any alternate material or method of construction provided any such alternate has been first approved and its use authorized by the Administrative Authority."

> "The Administrative Authority may approve any such alternate provided he finds that the proposed design is satisfactory and complies with the intent of this Code and the material offered is for the purpose intended, at least the equivalent of that prescribed in this Code, in quality, strength, effectiveness, durability and safety--."

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Section 401 - Materials in Chapter 4 (Drainage Systems) commences as follows:

(a) "Drainage piping shall be cast iron, galvanized steel, galvanized wrought iron, lead, copper, brass, ABS, PVC, extra strength vitrified clay pipe, or other approved materials having a smooth and uniform bore, except that:

1) (not relevant),
2) ABS and PVC DWV piping installation shall be limited to those structures where combustible construction is allowed."

In Chapter 5 (Vents and Venting) Section 503-Materials, it again stipulates that

2) "ABS and PVC DWV piping installation shall be limited to those structures where combustible construction is allowed."

The IAPMO Uniform Plumbing Code has installation standards for the use of both ABS (IAPMO IS 5-87) and PVC (IAPMO IS 9-87) in DWV pipe and fittings. In each case there is a note to the effect that

> "The Building Official shall be consulted about penetration of fire separations, height and area or other limitations."

In each case there is a section (315.6) dealing with Piping Installed in Fire Resistive Construction, stating

> "Where piping is installed and penetrates fire-resistive construction the fire-resistant integrity of the construction shall be as required by the Administrative Authority, or when not established by the building code, by qualified testing methods approved by the Administrative Authority. Approval shall be obtained prior to installing any such piping."

For obvious reasons, there is no such mention of penetration of fire-resistive construction in IAPMO IS 6-82 dealing with the installation of hubless cast iron sanitary systems.

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SBCCI Standard Plumbing Code (SPC)

The SBCCI Standard Building Code (1988) has 17 chapters dealing with the following issues:

Chapter	1	Administration
"	2	Definitions
"	3	Basic Principles
"	4	General Regulations
"	5	Materials
"	6	Joints and Connections
"	7	Traps and Clearouts
"	8	Interceptors - Separators and Backwater Valves
"	9	Plumbing Fixtures
"	10	Hangers and Supports
"	11	Indirect Waste Piping and Special Wastes
"	12	Water Supply and Distribution
"	13	Drainage System
"	14	Vent and Venting
"	15	Storm Drains
"	16	Alternate Designed Plumbing Systems
"	17	Reference Standards

In Chapter 5 on Materials (504.4.1), the code states that "Installations for plumbing drainage, waste and vents both above and below ground, indirect waste and storm drains shall conform to applicable standards in Table 500 and in conformity with Section 704.9 of the Standard Building Code." It also states that "Coextruded PVC plastic pipe shall be IPS Schedule 40 when used for drain, waste and vents".

The Table 500 materials (referred to above) for plastic DWV piping are listed below in Table 25. These include 1989/1990 revisions to the SBCCI code.

In Chapters 13 and 14 dealing with drainage systems and vents/venting, respectively, the first statements in each case (1301.1 and 1401.1) are to the effect that "Pipe, tubing and fittings for (drainage systems/the vent piping system) shall comply with the provisions of Chapter 5." Plastics are permitted in above- and below-ground DWV pipe sections.

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TABLE 25

SBCCI SPECIFICATIONS FOR PLASTICS USED IN DWV AND SEWER PIPE APPLICATIONS

Plastic Material/Application	ASTM Specification
ABS-DWV pipe and fittings	ASTM D 2661-87a, listed, see 504.4
ABS sewer pipe and fittings (for outside building sewers, storm drains and storm sewers)	ASTM D 2751-83a, see 1302.1, 1501.5, 1502.3 and 1502.4, installation: ASTM D 2321-83a
Type PS 46 PVC sewer pipe (for outside building sewers, storm drains and storm sewers)	ASTM F 789-85, see 1302.1, 1501.5, 1502.3 and 1502.4, installation; ASTM D 2321-83a
Acrylonitrile-butadiene-styrene (ABS) Schedule 40 plastic drain, Waste and vent pipe with a cellular core	ASTM F 628-87a, listed
PVC-DWV pipe and fittings	ASTM D 2665-87, listed, see 504.40
Type PSP PVC sewer pipe & fittings (for outside building sewers, storm drains and storm sewers)	ASTM D 3033-85, see 1302.1, 1501.5, 1502.3 and 1502.4, installation; ASTM D 2321-83a
Type PSM PVC sewer pipe & fittings (for outside building sewers, storm drains and storm sewers)	ASTM D 3034-85, see 1302.1, 1501.5, 1502.3 and 1502.4, installation; ASTM D 2321-83a
Type PSM PVC sewer pipe & fittings (for outside building sewers, storm drains and storm sewers)	ASTM D 3034-85a, see 1302.1, 1501.5, 1502.3 and 1502.4, installation; ASTM D 2321-83a
PVC sewer pipe & fittings (thin wall)	ASTM D 2729-85, for use under 504.1 only
PVC socket-type fittings Schedule 80	ASTM D 2467-87, listed
SRP-pipe and fittings	ASTM D 2852-81, see 504.1
Smoothwall polyethylene (PE) pipe for use in drainage and waste disposal absorption fields	ASTM F 810-85, for use under 504.1 only
Coextruded PVC plastic pipe	ASTM F 891-85, see 504.4.2, 504.6, 1302.1, 1501.5, 1502.3 and 1502.4
Flexible elastomeric non-pressure joints	ASTM D 3212-86, see 602.14

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A SYNOPSIS OF THE THREE MODEL BUILDING CODES AS THEY RELATE TO MATERIALS FOR DWV PIPE IN FIRE-RESISTIVE CONSTRUCTIONS

BOCA National Building Code (NBC)

The BOCA National Building Code (NBC) 1990 conforms in most important respects with those published by the ICBO and SBCCI. It is different to the extent that it has a separate chapter (Article 28) dealing with "Plumbing Systems". However, the word "material" seldom appears in these 5 pages, and the words "non-combustible" and "combustible" never appear. Rather the whole issue of the flammability of plumbing pipe and pipe fittings is dealt with in the sections of the code dealing with the fire-resistive nature of all materials embodied in buildings of all classifications.

The BOCA building occupancy classification system is essentially similar to that of the ICBO--namely,

Group A - Assembly
Group B - Business
Group E - Educational
Group F - Factory and industrial
Group H - High hazard
Group I - Institutional
Group M - Merchantile
Group R - Residential
Group S - Storage
Group U - Utility and miscellaneous

The types of construction under these 10 different classifications are Types 1-5 and the requirements for non-combustible materials used in these constructions by major application area (e.g., structural members, exterior walls) are summarized in Table 401, "Fire-resistive Ratings of Structure Elements (in Hours)". As for the use of combustible piping materials, the code states (p. 60) that it "is permitted in accordance with the mechanical and plumbing codes listed in Appendix A". And Appendix A is a list of referenced standards from ASTM, ANSI, BOCA, UL and other agencies.

In Section 602 the NBC defines high-rise buildings as "all buildings having floors used for human occupancy located more than 75 feet above the lowest level of fire department vehicle access". Assuming 30-40 feet for fire vehicle access, this would suggest a building of roughly 10 stories.

The fire-resistive character of the floors that DWV pipe have to penetrate is the key to BOCA limitations on pipe and pipe fitting

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materials. At the outset of Article 9 dealing with fire-resistive construction the code states that "Plans for buildings more than two stories in height shall indicate where penetrations will be made for electrical, mechanical, plumbing and communication conduits, pipes and systems, and shall also indicate the materials and methods for maintaining the required structural integrity, fire-resistive rating and fire-stopping."

On page 189 the code states that "Except where permitted by Sections 913.4.2.1 and 913.4.2.3, penetrations (of fire-resistive rated assemblies) for electrical, mechanical, plumbing and communications conduits, pipes and systems shall be installed in accordance with the approved ASTM E119 ("Test Methods for Fire Tests of Building Construction and Materials") rated assembly." Section 913.4.2.1 indicates that "Penetrations by non-combustible conduits, pipes and tubes through a fire-resistive rated floor assembly which connect not more than two stories (our emphasis) are permitted provided that the aggregate area of the penetrating items shall not exceed 1 sq. ft. in any 100 sq. ft. of floor area." Section 913.4.2.3 deals in similar terms with openings to accommodate non-combustible conduits, pipes, tubes or electrical outlets in a ceiling membrane which is an integral component of a fire-resistive rated floor assembly.

Later in Section 913.4.3.3 the code states that "Penetrations by vents, chimneys, cables, wires, air ducts, conduits, pipes and tubes through an unprotected floor assembly which connect not more than two stories are permitted provided that the annular space is protected with firestopping devices."

Later in the same chapter on Fire-resistive Construction the issue of shaft enclosures is raised and specific mention is made of cables and wires with combustible insulation and combustible pipes which penetrate a fire-rated shaft enclosure. These have to be tested in accordance with ASTM E119 or protected by an approved through-penetration protection system that is tested in accordance with ASTM E814 ("Test Method for Fire Tests of Through-Penetration Fire Stops").

The fire rating required for shaft enclosures is 2 hours in all constructions except for Type 5 where it is 1 hour. Yet in Article 6, "Special Use and Occupancy Requirements", in section 602 dealing with high-rise buildings, the code states that this fire rating can be reduced to 1 hour when automatic sprinklers are installed within the shafts at alternate floors.

It is noteworthy that the code allows for a 1-hour fire-resistive rating for exposed timber members when 5/8 inch Type X gypsum board

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is used to fire-protect the connectors and fasteners (page 173). The code also allows for the use of heat shields, separations and other approved means of fire protection for structural framing elements (p. 175) "where it can be shown to the code official that the structural integrity of (these) elements will not be reduced below a safe level by a fire within the building or in an adjacent building."

Further on in Article 9 on "Fire-resistive Construction" there is a treatment of fire-stopping materials in several applications, including ceiling and floor openings. Specifically, the code suggests that "Fire-stopping shall be provided at openings around vent pipes, ducts, chimneys and fireplaces at ceiling and floor levels, with non-combustible materials".

Then later again in Article 9 the issue of plenums is covered in the greatest detail of all three codes. The code allows for both combustible and non-combustible plenums. In the non-combustible plenum pipes must be non-combustible material and any insulation used to achieve this status must have a flame spread rating of 25 or less and a smoke-developed rating of 50 or less, tested to ASTM E84. Insulated wire must have a flame spread of 5 ft. or less when tested to UL 910. In the combustible plenums combustible materials, pipe and wire are permitted, but it is not clear from the code where and when such combustible plenums are permitted.

Finally, the NBC deals with insulated wire, stating that materials approved for use by UL and other approved agencies will be approved as meeting the requirements of the NBC.

ICBO Uniform Building Code (UBC)

The Uniform Building Code (UBC) published by the ICBO provides minimum standards regulating the design, construction, material, selection, use and occupancy, location and maintenance of all buildings within the ICBO jurisdiction. One of the dominant concerns evident in this (and the other two model building codes) is fire safety.

At the very outset of the UBC (p. 3), there is a statement to the effect that "The provisions of this code are not intended to prevent the use of any material or method of construction not specifically prescribed by this code, provided any alternate has been approved and its use authorized by the building official." Moreover, in the 1988 edition of the UBC the point is made (p. 1) that "The purpose of this code is not to create or otherwise establish or designate any particular class or group of persons who will or should be

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especially protected or benefitted by the terms of this code." One could translate these statements for our purposes to read, No Material, including plastics, is prescribed nor proscribed under this code as long as it meets the performance requirements established for critical building components. Moreover, no union or other group shall exercise authority over local building officials to exclude alternate materials or methods that can save on total material/labor/maintenance costs and at the same time satisfy the structural and fire-resistive standards of this code.

The types of buildings covered, by reference to occupancy, are covered in Part III (Chapters 5 through 12). The various occupancies or building functions are set out in Table 26 below. The various types of construction materials and methods are also set out in Part IV (Chapters 17 through 22). These are

- Types I and II - Fire-resistive buildings where the structural elements are all made of steel, iron, concrete or masonry
- Types III, IV and V - Buildings where the structural elements can be other materials permitted by the code (e.g., wood studding, plastics)

In Types I and II buildings, walls and permanent partitions have to be of non-combustible fire-resistive construction, although non-bearing partitions only require 1-2 hour fire-resistive construction. Type III, IV and V buildings must be of 1-hour fire-resistive construction throughout.

The issue of the combustibility of piping material arises in basically three different sections of the UBC. In Chapter 17, "Classification of All Buildings by Types of Construction and General Requirements", the issue of piping materials is raised explicitly under the section on "Shaft Enclosures". We reproduce this whole section below. It is here that the strictures on combustible materials in piping is set out rather clearly. Piping that extends vertically through shafts in a building of greater than 2 stories (if outside a building wall or, in other words, exposed) and of greater than 3 stories (if inside a building wall or chase) must be of non-combustible material.

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TABLE 26

ICBO UNITED BUILDING CODE (1988) BUILDING CLASSIFICATIONS BY OCCUPANCY

Group A

Buildings with stages or assembly rooms
Stadia, reviewing stands
Amusement parks

Group B

Gasoline service stations
Drinking and dining establishments
Wholesale and retail stores
Office buildings
Printing plants
Police and fire stations
Factories and workshops
Storage and sales rooms
Education buildings for students beyond 12th grade
Aircraft hangars
Open parking garages
Helistops
Power plants, pumping stations

Group E

Educational buildings for students through 12th grade
Day-care centers

Group H

Buildings holding hazardous materials
Aircraft repair hangars
Semiconductor fabrication facilities

Group I

Nurseries
Hospitals, sanitariums
Nursing homes
Jails, prisons, reformatories

Group M

Private garages, carports, sheds and agricultural buildings
Fences, tanks and towers

Group R

Hotels and apartment houses
Dwellings and lodging houses

Shaft Enclosures

Sec. 1706. (a) General. Openings extending vertically through floors shall be enclosed in a shaft of fire-resistive construction having the time period set forth in Table No. 17-A for "Shaft Enclosures." Protection for stairways shall be as specified in Sections 3309 and 3310. See Section 706 for exception in Group B, Division 4 Occupancies and Section 709 (j) for open parking garages.

Exceptions: 1. In other than Group 1 Occupancies, an enclosure will not be required for openings which serve only one adjacent floor and are not connected with openings serving other floors and which are not concealed within the building construction.

2. In buildings housing Group B Occupancies equipped with automatic sprinkler systems throughout, enclosures shall not be required for excalators where the top of the escalator opening at each story is provided with a draft curtain and automatic fire sprinklers are installed around the perimeter of the opening within 2 feet of the draft curtain. The draft curtain shall enclose the perimeter of the unenclosed opening and extend from the ceiling downward at least 12 inches on all sides. The spacing between sprinklers shall not exceed 6 feet.

3. In Type V buildings, chutes and dumbwaiter shafts with a cross-sectional area of not more than 9 square feet may be unenclosed if lined on the inside with lath and plaster or gypsum wallboard, with such lining covered with not less than No. 26 galvanized sheet metal gauge with all joints in such sheet metal locklapped. All openings into any such enclosure shall be protected by metal or metal-clad doors with either metal or metal-clad jambs, casings or frames.

4. Exit enclosures shall conform to the applicable provisions of Sections 3309 and 3310.

5. In one- and two-story buildings of other than Group 1 Occupancies, shafts for gas vents, factory-build chimneys or piping which extend through not more than two floors need not comply with Table No. 17-A. In Group R, Division 3 Occupancies less than three stories in height, shafts for gas vents and for ducts and piping which extend through not more than two floors need not comply with Table No. 17-A.

6. Gas vents and non-combustible piping installed in walls of buildings passing through three floors or less need not comply with Table No. 17-A. Such shafts shall be effectively draft-stopped at each floor or ceiling.

7. Non-combustible pipe and conduit may be installed and maintained within the cavity of fire-resistive walls, provided both the floor and wall penetrations are tightly sealed with a non-combustible material impervious to the passage of smoke.

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8. In buildings with Group H, Division 6 Occupancies, a fabrication area may have mechanical, duct and piping penetrations which extend through not more than two floors within that fabrication area. Penetrations for tubing, piping, conduit or duct shall be effectively draft-stopped at the floor level. The fabrication area, including the areas through which the ductwork and piping extend, shall be considered a single conditioned environment.

(b) Protection of Openings. Every opening into a shaft enclosure shall be protected by a self-closing fire aslembly conforming to Section 4306 and having a fire-protection rating of one hour for openings through one-hour walls and one and one-half hours for openings through two-hour walls.

Exceptions: 1. Openings to the exterior may be unprotected when so permitted by Table No. 5-A.

2. Openings produced by air ducts piercing shaft enclosure walls may be protected by fire dampers conforming to U.B.C. Standard No. 43-7.

(c) Rubbish and Linen Chutes. In other than Group R, Division 3 Occupancies, rubbish and linen shutes shall terminate in rooms separated from the remainder of the vuilding by a one-hour fire-risistive occupancy separation. Openings into the chutes and termination rooms shall not be located in exit corridors or stairways.

The issue of the combustibility of piping material is also raised in Chapter 43 under "Fire-resistive Standards". Here (on p. 701) the code states that "Fire-resistive floors shall be continuous and all openings for mechanical and electrical equipment shall be enclosed as specified in Section 1706." The code goes on the say that "Occasional pipes, conduits, sleeves and electrical outlets of copper, sheet metal or ferrous construction may be installed within or through fire-resistive floor systems, provided that such installations do not unduly impair the required fire resistance of the assembly. The space between the pipe, conduit and sleeves and the floor shall be designed to prevent the movement of hot flames or gases." Then the code states that "The provisions of this section shall not apply when such openings are in accordance with the results of tests conducted pursuant to the provisions of Section 4302(b)." And Section 4302(b), as we read it, allows for tests to prove the fire resistance of alternate materials--that is, those other than copper, sheet metal and ferrous construction. This appears to us to be a primary focus for any future challenge to the UBC to allow the use of plastic substrate piping that is adequately protected against fire damage.

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The issue of penetration of fire-resistive building structures is also raised in p. 700 in the context of walls. Here the code rules that

(e) Penetrations. Penetrations in walls requiring protected openings shall be fire stopped. Firestopping shall be of an approved material securely installed and capable of maintaining its integrity when subjected to test temperatures prescribed in U.B.C. Standard No. 43-1 for the specific wall or partition.

Openings in walls and partitions shall be protected as specified in Section 4306. Where fire-rated walls and partitions require protected openings, the following penetrations into or through such construction are permitted:

1. Copper or ferrous pipes or conduits may penetrate the walls or partitions, provided firestopping is provided in accordance with the first paragraph of this section.

2. Openings for steel electrical outlet boxes not exceeding 16 square inches in area, provided the area of such openings does not aggregate more than 100 square inches for any 100 square feet of wall or partition area. Outlet boxes on opposite sides of walls or partitions shall be separated by a horizontal distance of 24 inches.

3. Where walls are penetrated by other materials or where larger openings are required than permitted in Item 2 above, they shall be qualified by tests conducted in accordance with the provisions of Section 4302 (b).

The space between the penetrating materials described in Items 1, 2 and 3 and the wall shall be designed to prevent the movement of hot flame or gases.

As we read it, this again allows plastic and other inherently combustible materials to penetrate these fire-resistive structures as long as fire-stopping devices are used. And we cite later in this report the recent emergence of fire-stopping devices suitable for use with plastic DWV pipe.

The other references to piping and pipe materials occur in the Appendices to the UBC. On page 821, Appendix to Chapter 1, Division II entitled "Life-Safety Requirements for Existing High-rise Buildings", the code states

7. Vertical shaft enclosures. Openings through two or more floors except mezzanine floors, which contain a stairway or elevator, shall be provided with vertical shaft enclosure protection as specified herein. Such floor openings, when not enclosed by existing shaft

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enclosure construction, shall be protected by one-hour fire-resistive-rated shaft enclosure construction. For floor openings which are enclosed by existing shaft enclosure construction having fire-resistive capabilities similar to wood lath and plaster in good condition, $\frac{1}{2}$-inch gypsum wallboard or approved $\frac{1}{4}$-inch-thick wired glass is acceptable. Wired glass set in a steel frame may be installed in existing shaft enclosure walls but shall be rendered inoperative and be fixed in a closed position.

Openings through two or more floors for other than stairways or elevators, such as openings provided for piping, ducts, gas vents, dumbwaiters, and rubbish and linen chutes, shall be provided with vertical shaft enclosure protection as specified for stairways and elevators.

Exception: Openings for piping, ducts, gas vents, dumbwaiters and rubbish and linen chutes of copper or ferrous construction are permitted without a shaft enclosure, provided the floor openings are effectively fire-stopped at each floor level.

Finally, on page 860, Appendix to Chapter 38, we have the only mention of cast iron perhaps in the whole UBC (all 926 pages of it) where it deals with "Basement Pipe Inlets". Here the code stipulates that "all basement pipe inlets shall be of cast iron, steel, brass or bronze with lids of cast brass or bronze".

SBCCI Standard Building Code (SCB)

The latest edition of the SBCCI's Standard Building Code (SBC) was published in 1988, and there are 1989/1990 revisions to the code. Of all three national model building codes, the SBC is, at least at face value, the least restrictive in terms of allowing the use of combustible materials in DWV and other piping systems in multi-story buildings of all types. The SBC provides the minimum detail on materials allowable to meet fire-resistive requirements for the various elements of building construction. This leaves the interpretation of the code wide open to proponents of different material systems, and it is, therefore, not surprising that we find more multi-story building approvals for plastic DWV pipe in the areas of the country under SBCCI jurisdiction (e.g., Florida and Georgia) than any other areas of the country.

Even the Preface to the SBC alerts the reader to this greater latitude in material selection and approval. It includes the statements:

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"The use of performance-based requirements encourages the use of innovative building designs, materials and construction systems while at the same time recognizing the merits of the more traditional materials and systems. This concept promotes maximum flexibility in building design and construction as well as assuring a high degree of life safety."

"The Standard Building Code incorporates, by reference, nationally recognized consensus standards for use in judging the performance of materials and systems. This provides for the equal treatment of both innovative and traditional materials and systems, provides for the efficient introduction of new materials into the construction process, and assures a high level of consumer protection."

This wide latitude to new (innovative) materials is reinforced in the very first Chapter dealing with "Administration" where the code states (p. 3) under "Alternate Materials and Methods":

"The provisions of this Code are not intended to prevent the use of any material or method of construction not specifically prescribed by this Code, provided any such alternate has been approved by the Building Official. The Building Official shall approve any such alternate, provided he finds that the alternate for the purpose intended is at least the equivalent of that prescribed in this Code in quality, strength, effectiveness, fire resistance, durability and safety. The Building Official shall require that sufficient evidence or proof be submitted to substantiate any claim made regarding the alternate."

Occupancy categories in the SBC are virtually identical to those in the NBC--namely,

Group A - Assembly
Group B - Business
Group E - Educational
Group F - Factory Industrial
Group H - Hazardous
Group I - Institutional
Group M - Merchantile
Group R - Residential
Group S - Storage

The only missing category from the NBC's listing is Group U - Utility and Miscellaneous.

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The types of construction defined by the SBC are also virtually identical to those of the UBC and NBC, except that the SBC includes a Type VI building. The types are as follows:

Type I) Type II) Type III)	2-4 hour fire-protected
Type IV) Type V) Type VI)	1-hour fire-protected or unprotected

Chapter 7 of the SBC covers "Fire Protection Requirements" where it states that "all openings, including vertical shafts, in floors or roofs, shall be enclosed or otherwise protected to prevent spread of fire from story to story, unless specifically excepted in this Code". Among the exceptions are

1) openings in floors and roofs of 1- and 2-family dwellings need not be enclosed, and
2) in non-residential buildings (other than Group E, I and R occupancies), there is no need for an enclosure for openings that serve only one adjacent floor, are not connected with openings serving other floors, and are not concealed within the building construction.

The penetration by combustible and non-combustible pipe is dealt with in two ways. First Table 705.1 sets out the allowable fire protection methods for penetrating non-fire-resistive assemblies. Then Table 1001.3 (which is a new table in the 1989/1990 revisions) sets out the allowable fire protection methods for penetrating fire-resistive assemblies. We reproduce both these tables below.

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TABLE 27

ALLOWABLE PROTECTION METHODS FOR PENETRATION OF NON-FIRE-RESISTANT ASSEMBLIES IN THE SBCCI STANDARD BUILDING CODE

	Conduit Pipes & Tubes		Ducts		Factory Built Appliance Vents And Chimneys		Cables & Wires
	Penetrating Material Classification[1]						
Building Location	N	C	N	C	N	C	All
Penetration Thru 3 Floors or More (Connecting 4 Stories or More)	A		A		A		A
Penetration Thru 2 Floors Maximum (Connecting 3 Stories Maximum)	A,B C	A,B	A,B or D	A or B	A,B or C	A or B	A,B
Penetration Thru 1 Floor Maximum (Connecting 2 Stories Maximum)	A,B,C		A,B,C or D		A,B or C		A,B,C
Penetration Thru Roof-Ceiling Assembly	No Requirement						
Penetration Thru Roof Membrane Only	No Requirement						

Notes: N = Non-combustible penetrating material.
C = Combustible penetrating material.

Method A - A two-hour fire-resistant shaft enclosure, in accordance with 701.3.

Method B - One-hour fire-resistant shaft enclosure, in accordance with 701.3.

Method C - Protection of the annular space around the penetrating item in accordance with 1001.3.5.

Method D - Installation of an approved ceiling damper or fire damper in a duct penetration in accordance with its listing.

Method E - Use of an approved through-penetration protection system tested and installed in accordance with 1001.3.6.

Method F - Penetrations tested in accordance with ASTM E 119 as part of the fire resistant assembly.

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TABLE 28

ALLOWABLE PROTECTION METHODS FOR PENETRATION OF FIRE-RESISTANT ASSEMBLIES IN THE SBCCI STANDARD BUILDING CODE

			Conduit Pipes & Tubes		Ducts		Factory Built Appliance Vents And Chimneys		Cables & Wires
			Penetrating Material Classification[4]						
			N	C	N	C	N	C	All
Penetration Thru 3 Floors or More (Connecting 4 Stories or More)			A,E or F	A or E	A		A		A or E
Penetration Thru 2 Floors Maximum (Connecting 3 Stories Maximum)			A,B E, or F		A or B		A or B		A,B E or F
Penetration Thru 1 Floor Maximum (Connecting 2 Stories Maximum)	Monolithic Fire Rated Assembly		A,B, C2,E, or F	A,B, E, or F	A,B, or D2[3]		A,B, or C2	A or B	A,B, C2, E, or F
	Fire Rated Assembly With Membrane Protection	Ceiling Membrane Penetrated	A,B, C1[2] E, or F		A,B, D1[2] or F		A,B, or C1[2]		A,B, C1[2] E or F
		Floor Membrane Penetrated	A,B, C2, E, or F		A,B or D2[3]		A,B or C2		A,B, C2 E, or F
Penetration Thru Roof-Ceiling Assembly	Ceiling Membrane		A,B, C1[2] E, or F		A,B D1[2] or F		A,B, or C1[2]		A,B,C1[2] E or F
	Roof Membrane		No Requirement						
Penetration Thru Roof Membrane Only									

Notes:

1. Letters in the table refer to protection methods described in footnotes to Table 27.
2. Aggregate area of openings shall not exceed 100 sq. in./100 sq. ft.
3. Duct shall be part of a fully ducted system (transfer grills shall not be permited).
4. N = non-combustible penetrating material.
   C = combustible penetrating material.

C1 = Protection at the ceiling line.
C2 = Protection at the floor line.
D1 = Ceiling damper at the ceiling line.
D2 = Fire damper at the floor line.

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Thus, according to the SBC, combustible (plastic) pipe can be used in buildings of any height as long as the construction of the shaft enclosure is 2-hour rated or at least the fire rating of the floor or ceiling being penetrated. The same applies to ducting, vents, and wire and cable (all of which are or can be made of plastic materials). The code also specifies the use of firestopping devices for all walls and partitions, and the annular space around pipes have to be fire-protected.

In sections 704.9 and 1001.3 the possible use of combustible pipe (as well as wire and cable with combustible jacketing) is raised explicitly and, as indicated in Table 21 above, the materials and the methods have to be tested to ensure the duration of fire protection classified as Method A through F (see footnotes to Table 21).

Interestingly, the requirements for piping material in plenum spaces is covered, not in the building code, but rather in the Standard Mechanical Code of the SBBCI.

In Chapter 10, headed "Fire Resistance Standards for Materials and Construction", the code refers to materials, thicknesses and assemblies that have to perform to tests made by a recognized laboratory in accordance with the requirements of ASTM E119 and E814. Other than that, this chapter is very brief and rather vague on the requirements for approving combustible piping in buildings of the various types. For example, the whole chapter is only 5 pages long. And, in fact, Chapters 7 and 10 of the SBC dealing with "Fire Protection Requirements" and "Fire-Resistive Standards for Materials and Construction" are a combined 29 pages whereas Articles 9 and 10 of the NBC covering "Fire-resistive Construction" and "Fire Protection Systems" are a combined 72 pages.

CONSULTATIONS WITH MODEL CODE OFFICIALS

We attempted to consult with officials at all three model building code-writing organizations with only partial success. The policy at BOCA is to restrict consultations with building code engineers to BOCA members. At SBCCI I spoke briefly with Doug Connell, a plan review engineer, who was only marginally cooperative, but he did say that plastic DWV pipe is being used in fire-rated buildings in Florida, and he referred me to some mechanical engineering firms in Atlanta, Georgia.

The best contact that we were able to make in the model building code orgainizations was with John Trau who is the vice president of

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codes engineering at ICBO headquarters in Whittier, California. Trau explained in the course of our conversation that ICBO has 3 district offices in

- -Austin, TX
- -Kansas City, MO
- -Seattle, WA

He also indicated that there is a widespread misconception that ICBO only has jurisdiction "west of the Mississippi River". In fact, ICBO (and its sister organization, IAPMO) codes have been adopted by

- -all states west of the Mississippi River
- -Puerto Rico
- -Saudi Arabia
- -Virgin Islands
- -Trust Areas of the Pacific

Trau claims that this broad acceptance of ICBO and IAPMO standards is due to the fact that they each provide the best technical set of building and plumbing guidelines in North America.

I asked Trau about the statements in Sections 401 and 503 of the IAPMO Uniform Plumbing Code (UPC) indicating that plastic (ABS and PVC) DWV piping installations shall be limited to those structures where combustible construction is allowed. In other words, when and how did the issue of combustibility (obviously detrimental to plastics industry interests) get introduced into the UPC code? In answering that question and in discussing other related issues later in our conversation, it was immediately apparent that Trau disagreed totally with those sections of the code and that he is favorable (or at least neutral) to plastic piping being used in DWV and other interior building pipe applications.

Trau stated that the introduction of the term "combustibility" was at the initiative of IAPMO plumbing officials who were, in the main, former professional plumbers and, therefore, members of the United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada. The revision to the code was made at the time of the 1988 revisions. Trau regarded that particular revision as totally inappropriate insofar as combustibility is a building fire safety issue, not a functional plumbing issue, and as such it lies within the jurisdiction of the building officials (i.e., the ICBO). The ICBO position vis-a-vis IAPMO has always been: you deal with the issues germane to plumbing and leave the fire/smoke/toxicity issues to the building people

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who have to deal with the local fire marshalls. And Trau says that the ICBO has actually prepared an emergency amendment to adopt the latest UPC, but to delete those sections referring to combustible materials, recommending that that issue be left to building code officials. This is the first topic on the agenda of the first day of the next ICBO annual meeting to be held September 12 in Denver, Colorado. Trau noted that everyone anticipates a "lively discussion" over this issue.

Trau feels that it is "asinine" to propose that the smoke from burning plastic DWV pipe is potentially life-threatening, a classic "smoke screen". The fact of the matter is that there are already combustible materials incorporated into code-approved assemblies in high-rise buildings, "right up to 90 stories high". The further fact is that the plenum space that the plumbers argue cannot be penetrated by combustible material is already loaded with plastic-insulated wire and cable and wire/cable harnesses, fiberglass ducts, and plastic electrical fixtures and fasteners. So, by implication, the plastic pipe people can make a good case that their products are being singled out for exclusion in a totally discriminating manner. One can justifiably claim that we should not add any more combustible material into these ceiling spaces, but that has not been the thrust of the plumbers' contention.

The plumbers' union also points to the issue of leaching from plastic pipe walls. That is a valid issue, but it doesn't apply to DWV pipe and it also applies to metallic water distribution pipes. The biggest furor today in the ICBO jurisdiction from a plumbing standpoint is the whole area of polybutylene in water distribution pipes. There is also concern about plastic water distribution pipe failures due to faulty installation. Those are proper issues within the jurisdiction of the union. But smoke, toxicity and fire resistance are clearly outside their expertise.

I questioned Trau on the other problems associated with plastic DWV pipe--namely,

-excessive expansion and contraction
-excessive noise in multi-story constructions

He agreed that these (and others) were indeed problems, but he also emphasized that they were all addressable with the proper engineering design. None of these are sufficient cause to prohibit plastics from DWV pipe. The real issue is cost-effectiveness, and Trau pointed out at the outset of our conversation that plastic DWV pipe is, in the main, the quickest, cheapest installed material for these applications. Hence, the opposition from the plumbers' union.

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Trau noted repeatedly that the issue has been politicized--between the ICBO and IAPMO organization, between the metal-benders of the union and the plastics resin/pipe people, and even among the politicians of certain states. The union is very influential. Through its Pipe Trust, it publishes a periodic bulletin that puts out the anti-plastic pipe line that Trau and ICBO officials categorically dispute. However, it does reach the mechanical engineers and, since it carries some credibility, it does influence their materials decision-making. That's why the ICBO has to tackle this later this year at its annual meeting--to counter the misinformation and to promote the correct, objective, fair interpretation of what the code allows and doesn't allow in specific circumstances.

LOCAL CODES: A SELECTION OF CITIES AND STATES

CALIFORNIA/ALASKA

I spoke with John Meecham, an official within IAPMO in Los Angeles. He indicated that most of the Western states have adopted the UPC 1988 as it stands and, therefore, they permit the use of plastic DWV pipe in non-residential buildings, except in Class 1 or 2 buildings which are designed to be non-combustible buildings. In effect, these states allow PVC/ABS DWV piping in 3-4 story commercial buildings if the building code permits a wood frame construction. It can only be used in 5-story or higher commercial buildings if there is a full water sprinkler system installed.

In California and Alaska the local chapters of the United Association of Journeymen & Apprentices of the Plumbing & Pipe Fitting Industry of the U.S. and Canada have been able to enforce a prohibition on the use of plastic DWV. In 1991 the UPC comes up for revision, and Meecham feels that the union may not be able to counter the growing pressure for plastic piping coming from the building contractors and the plastics industry.

Meecham also indicated that the UPC as it stands prohibits the use of plastic piping in hot and cold water feeds within commercial buildings, but it does allow plastic piping outside the building. Once the piping enters the building, only CPVC qualifies as an alternate to copper or cast iron pipe due to its superior heat resistance.

CHICAGO

On May 16, 1990 the Chicago city council revised its building code to (inter alia) allow plastic DWV pipe in residential buildings up to 3 stories high (see attached Plastics News article on page 101). Chicago had been the last U.S. city of more that 350,000 people to

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prohibit the use of plastic DWV pipe in multi-story residential buildings. However, it continues to bar plastic DWV pipe from non-residential buildings.

Daniel Weil, the Chicago Building Inspector, had recommended the partial removal of the plastic DWV pipe ban to Mayor Richard Daley, and Daley had incorporated the revision into a legislation package submitted in March to reform the Chicago Building Department building code. Daley and Weil, in effect, took on a number of local unions and agencies opposed to plastic DWV pipe--namely,

-the local UA Local 130
-the Firefighters Union Local 2
-the Federation of Labor
-the Building Trades Council
-the Plumbing Contractors Association of Chicago

The rhetoric of the issue boiled down to cost savings for affordable housing versus the safety of the material and the labor displaced by switching from cast iron pipe.

Chicago had become isolated in its refusal to allow plastic DWV pipe--among other large cities and even in the Cook County area. In the Cook County suburbs surrounding Chicago, 70% of communities allow plastic DWV pipe and in Will County to the south 88% of communities allow it. And there had been no reports of plastic pipe failure or safety hazards from these communities.

I called the Chicago Building Inspector's office and a Mr. Ratliff later returned my call. He indicated that the recently passed ordinance only applies to residential buildings--not because he and Daniel Weil didn't feel that plastic DWV pipe isn't advisable for use in non-residential buildings, but rather because that was the only realistic option for passing the ordinance and "getting a foot in the door". They genuinely feel that plastic DWV pipe is both safe and cost-effective and that its use can enhance affordable housing construction materials and practices in Chicago. But the extent of opposition to the use of this pipe anywhere in Chicago was so strong that they decided to leave the issue of the non-residential building code to a later day. And (in Ratliff's words) "that probably won't be too soon".

The real issues here were safety and jobs. The firefighters' union argued that plastic pipe is inherently dangerous insofar as it can be burning behind a wall and, therefore, be invisible as a risk to occupants and firefighters. The Building Inspector's office acknowledged this risk, but then successfully challenged the union to provide

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evidence that this had in fact endangered or lost lives in the past. The plumbers' union pointed to the danger of using plastics in water distribution systems and to the health hazards associated with the solvent welding of these pipes. The Building Inspector responded to these points by arguing that the ordinance only deals with DWV, not water supply, so that is a red herring. Secondly, it again challenged the plumbers' union to cite specific evidence of health impairment due to the use of these solvents in normal on-site circumstances. And Ratliff adds that the city council by its action is not <u>mandating</u> the use of plastic DWV pipe in residences; it is simply <u>permitting</u> it as an option.

Ratliff referred to the fire at the MGM Hotel in Las Vegas as an incident raised, in a sense, by both sides. To the opponents of plastic DWV that fire was a demonstration of the dangers of plastics in multi-story buildings; to the proponents of plastic pipe it demonstrated the approval of this type of pipe elsewhere in the country.

In the end, the most compelling argument in favor of plastic DWV pipe, in Ratliff's view, is that this is an option all around the country and the same plumbers who are fighting against the plastic pipe option in Chicago are using it in the Chicago suburbs. I asked him whether the plastics industry representatives were active in this debate over the ordinance, and he answered that they weren't, certainly not during the hearings.

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Chicago approves PVC for outtake pipes

By Bill Bregar
PLASTICS NEWS STAFF

Winning a long battle with labor unions, Chicago Mayor Richard M. Daley has convinced City Council to change the building code and allow plastic pipe in drain, waste and vent (DWV) applications.

The council voted 29-12 on May 16 to allow PVC pipe in DWV, or "outtake," uses in residential buildings up to three stories high. Chicago had been the last U.S. city of more than 350,000 people to bar plastic DWV pipe, according to Chicago Building Inspector Daniel Weil.

Framing the issue in "affordable housing" terms, Daley introduced the ordinance to the council in March as part of a legislation package to reform the Chicago Building Departmen' and building code. Weil had recommended the plastic-pipe measure to Daley.

Weil praised Daley's strong leadership for getting the ordinance approved in a city known for politically strong unions. Daley's three immediate predecessors had tried unsuccessfully to loosen the building code.

"[Daley] got it done. That speaks for itself," Weil said in a telephone interview last week.

Chicago-area unions opposing plastic pipe included the Journeymen Plumbers Union Local 130, Firefighters Union Local 2, the Federation of Labor and the Building Trades Council. The Plumbing Contractors Association of Chicago also opposed the building-code change.

Weil said the groups were not involved actively in recent lobbying for or against the measure.

Officials from the Plastic Pipe and Fittings Association, a Glen Ellyn, Ill., trade organization that represents makers of DWV and other types of pipe, could not be reached for comment.

"We're elated," said Marc Palasini, national sales manager at Freedom Plastics Inc., a pipe extruder located about 90 miles northwest of Chicago in Janesville, Wis. "It's definitely going to increase our market share in Chicago. We feel it's time they did it."

Palasini said Freedom Plastics already has a good market because of PVC pipe used in suburban development.

A central issue in the debate was the cost savings of using plastic pipe over metal pipe. Daley said plastic pipe can encourage housing rehabilitation. Weil declined to give specific cost savings, and opponents of plastic pipe have said any labor cost savings offered by plastic pipe is insignificant compared to the cost of a house.

Perhaps even more important: Chicago was becoming isolated in its refusal to allow plastic pipe in DWV applications.

In the part of Cook County surrounding Chicago, 70 percent of communities allow plastic DWV pipe, Weil said. Just to the south, in Will County, 88 percent of communities allow it. Weil said there are no reports of plastic DWV pipe causing "adverse effects" in those communities.

Union officials charged that plastic pipe is hazardous in a fire and solvents used to connect pipe lengths are hazardous to plumbers' health.

"We don't feel it's a good material," said Jim McCarthy, Plumbers Local 130 business manager.

But Weil said the fire-hazard argument has not been proven and "is clearly not relevant given the amount of plastic already in everybody's homes." The alleged solvent danger "also falls in on its own weight because the same plumbers are installing it all over the suburban communities."

Plumbers already face hazards from solder and blow torches used to install metal pipe, the building commissioner said.

During the heated City Council debate, one alderman conducted a plastic "show and tell" of household objects made of plastic, including condiment bottles and toothpaste tubes.

"It's not as if this is all of a sudden introducing plastic in everybody's homes," Weil said.

Even with the change, Weil said, many Chicago homeowners will stick with metal pipe because of concerns about plastics' durability, pipe noise and fears that plastics will fail.

Daley does not expect political punishment from the unions for his pro-plastics stance, said Noelle Gaffney, the mayor's assistant press secretary.

Weil said he has no plans to change the city's building codes even further to allow plastics in "intake" pipes carrying potable water into homes.

"The issue is not even on the table at this point," he said.

California state officials are expected to issue a final environmental impact report this summer on that issue, after nearly 10 years of debate.

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Source: Plastics News, June 4, 1990.

CONNECTICUT

In order to obtain an assessment of the local (Connecticut) prospects for plastic DWV piping in multi-story buildings, we consulted with the plumbing inspector in the local (Norwalk, CT) building department. We also consulted with a leading local plumbing contractor based in New Haven, CT. The information and impressions drawn from these two sources were almost 180° different.

Marty Sphar, the plumbing inspector in Norwalk, indicated that they follow the Connecticut state code which follows the BOCA code. This permits the use of plastic DWV pipe and, in fact, "plastic pipe is used all the time in high-rise building DWV". When I asked about the fire protection of such pipe, he replied that the plastic pipe is generally encased in a fireproof shaft of several layers of sheet rock as it passes through floors. That provides a 2-hour fire-rated piping system. As for the use of horizontal DWV plastic pipe, it can't be used where the dropped ceilings serve as return air plenums, but it can be used where the return air is ducted. He repeated that today plastic DWV pipe is in widespread use in high-rise buildings insofar as it involves lower labor costs.

Sphar then recommended that I confirm this impression with James Ursini of New Haven, Connecticut, a leading New England plumbing contractor. Arthur Spose, vice president, told me that in view of the new fire code, cast iron is the most cost-effective DWV pipe material and plastics (e.g., PVC) is seldom used. The problem with plastics is that you need either special fittings or a fireproof shaft to penetrate horizontal and vertical fire walls. When I mentioned the views of the Norwalk plumbing inspector and the option of a fireproof shaft of sheet rock, Spose laughed off this idea on the grounds that the total cost of such an option would exceed that of cast iron. In the recently completed Merritt Seven office complex in Norwalk, cast iron was used in every case except one--in a garage plumbing application. As for New York City where James Ursini regularly quotes jobs, the convention is cast iron pipe with lead joints. Spose claims that you won't find any plastic DWV pipe in New York City.

NEW YORK CITY

I called the office of Rudolph Rinaldi who is the Commissioner of Buildings of the city of New York. A secretary in Rinaldi's office recommended that I call a Mr. Shukla in the Plumbing Code section of the city government, and Shulka referred me to Murray Lipstein who is the Chief Plumbing Inspector for the five boroughs of New York City.

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Lipstein's reply to my query regarding the scope for plastics in DWV and other piping in New York City high-rise buildings was short and sweet as the ass's gallop--namely, "No way, forget it." He told me that the New York City code only allows plastic DWV piping in residences of 3 stories or less and for display fountains in the front of buildings. In all other interior building pipe applications, "No way".

I asked Lipstein whether this reflects his views or that of the plumbers' union, and he replied that it reflects the views of the New York City fire department; they strenuously oppose the use of any plastic materials in high-rise construction where there are more fire-protected alternatives. I then asked Lipstein whether this current sentiment against plastics might change in the future. "No", he replied, "My opinion is that it's going to get more strict because no one wants it." He indicated that he had just come from a meeting where some group was proposing an alternative to conventional steel gas piping--namely, flexible stainless steel pipe with a thick plastic coating on the exterior. The proposal was turned down, not only because it involved more lines of piping, but because the plastic skin on the pipe would represent a hazard in a fire situation.

MECHANICAL ENGINEERING FIRMS: A SAMPLE

Brady & Anglin

Brady & Anglin is a major mechanical engineering firm in Atlanta, Georgia, and I spoke with Lionel Grindstaff who is an associate at the firm. He indicated at the outset that the SBCCI plumbing code did not prohibit plastic DWV pipe. However, the SBCCI building code did indirectly.

The main problem with using combustible DWV pipe is the now common practice of building plenum air spaces into high-rise buildings for the HVAC systems. You can't have a plastic pipe exposed in a plenum air space since it can catch fire and send smoke throughout the building through the HVAC. You can chase in the vertical DWV pipe lengths behind gypsum board, but you can't chase in horizontal runs with hangers, etc.

Grindstaff also referred to the problem of penetrating fire-resistive floors with plastic pipe. If the pipe burns, you have now got a hole for a fire to run through. The solution to this problem might be to use a fire-stopping device, and he referred specifically to the Proset system.

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The third problem that Grindstaff alluded to is excess noise in the operation of plastic DWV pipes. He contends that water flushed through a plastic DWV pipe assembly sounds like "a bucket of water is coming through the wall". This would be "really terrible for a first-class office building".

Grindstaff claims that Brady & Anglin has never nor will they ever use plastic DWV pipe (rather than cast iron) in its high-rise building contracts. Where they are considering the possibility of plastic pipe is in fire sprinkler systems, and he referred to the Blazemaster piping which is UL-approved and permitted in return air plenums. The reason why plastic pipe works in this case is that it's always filled with water whereas the DWV pipe is generally empty.

Burton & Van Houlten

I had an excellent conversation with Gary Lombardi who is the Senior Plumbing Engineer at Burton & Van Houlten of West Hartford, Connecticut, one of the state's largest mechanical engineering firms. It was excellent to the extent that Lombardi's comments and insights were wide-ranging and (I believe) objective, and I suspect that they reflect the views of the engineering community here in Connecticut.

Lombardi began by saying that there is nothing in the national (BOCA) nor state building code that prohibits the use of plastic DWV pipe in residential and non-residential construction, single- or multi-story. Yet whereas plastic DWV pipe is often used in large, multi-story residential (e.g., condominium) complexes, it is seldom used (and even then, only selectively) in non-residential buildings of any size, particularly high-rise. The reasons are basically four-fold:

1) First and foremost, PVC (and other plastic) pipe will emit smoke when exposed to a flame and this is unacceptable in non-residential building design today.
2) Plastic pipe will cease to function in a fire and will need replacement if the basic building survives whereas cast iron pipe will generally survive all but the most severe fire situations.
3) All plastic pipe systems have serious problems with expansion and contraction in varying environmental conditions, and this is a particularly serious problem in DWV piping.
4) The noise generated by operating plastic DWV piping systems is a drawback in residential buildings, but it is simply unacceptable in quality multi-story non-residential buildings.

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Lombardi stated that the policy at Burton & Van Houlten is to avoid the use of plastic DWV piping except in very limited circumstances. Usually these are drainage and venting pipes that can be roughed into fire-rated walls. Here the issues of smoke and noise can be addressed adequately. However, since cast iron is generally specified for soil pipes (that is, no hub cast iron above ground and bell and spigot units below ground) the practice is to spec in cast iron for the whole system to avoid

1) the need for special fittings to link the cast iron to the plastic pipe lines, and
2) the risk that building contractors and/or their workmen on the site may use the plastic pipe where it would violate the building code or any arrangement made in advance with the local building official.

One of the main reasons why cast iron is universally used in horizontal soil pipes in multi-story buildings is that they are designed into the hung ceiling area with other services (i.e., cold and hot water feeds, wire and cable, ventilation ducts, water sprinkler systems, etc.). The trend today is toward the use of return air plenum systems--that is, using the whole space above the hung ceiling to return the air from the heating/ cooling system. First of all, this is far less expensive (roughly half the cost) than ducted air spaces using sheet metal or fiberglass ducts. Secondly, with the growing emphasis on cost containment in non-residential building and maintenance, the design engineers are now being allowed less and less ceiling space to work in. As Lombardi says, if you save 4" per ceiling space on a 20-40 story building, you've saved a tremendous amount of total building costs. Thirdly, the other trend evident on the East Coast is VAV (variable air volume) systems where the air flow is varied through the fan boxes, proportionate to the size of the room, and then vented back through the plenum space. It controls costs of heating/cooling better and also saves on ceiling space. And once again, plastic pipe is not permitted in these circumstances because of the risk of spreading smoke through the heating/cooling system in the event of a fire.

Noise is also a major concern in Lombardi's preference for avoiding plastic DWV pipe. He claims, "I've had no end of complaints on that" from apartment building occupants and owners. The fact is that Burton & Van Houlten generally specs in cast iron DWV pipe, but then the building is "value-engineered"--that is, the contractor, the customer and the owner get together to determine cost-cutting procedures and/or materials. So Lombardi may have spec'd in cast iron, but the builders build in PVC at the job-site. Then the

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apartment units are rented or sold and complaints pour in relative to the excessive noise of flushed water through the pipes. Lombardi claims to have first-hand knowledge of this as an architect friend of his lives in such a unit and he has come to him for "solutions" to the PVC DWV pipe noise problem.

Another problem with plastic is clearing out blockages. He recalled the manager of a home for the elderly calling to ask about clearing DWV blockage. Lombardi recommended that he call Roto-Rooter to fix the problem. Later the manager called him back to say that the Roto-Rooter service people had come, they had started to clear out the pipes, and the pipes had burst. The problem was that whereas Lombardi had spec'd in cast iron, the building contractor had substituted PVC and the Roto-Rooter equipment had cut right through the plastic pipe walls.

Lombardi claims that they have no problem with the cast iron DWV pipe from expansion and contraction in horizontal or vertical pipe sections. The no hub system is designed to tolerate such movement. The solvent welded plastic is not, and the misalignment of drain pipes can cause real problems. Moreover, the building contractor will often cheat on the proper spacing of hangers and supports on the plastic soil pipes, and during the hot summer months when the plastic softens and expands, the pipe sags "like a garden hose".

Lombardi stresses that the performance of cast iron DWV pipe has never been questioned. It is designed to survive corrosion and other environmental forces for 50 years whereas the typical life of a non-residential building is 20-40 years before retrofitting. And now that resin prices have increased, he suspects that the total installed cost of cast iron is lower than that of PVC or ABS DWV pipe. That wasn't always the case where cast iron was chosen on performance terms, not total installed cost terms.

Lombardi concluded by saying that even if all the other performance features of plastic DWV pipe could be improved, the smoke factor would still be daunting. In order to get a 1-3 hour fire rating, the inherent flame resistance of the plastic material must be improved and an exterior fire protection system must be incorporated onto the pipes and fittings. One could in theory wrap or coat them to provide the requisite fire protection, but now you need a tested assembly and this introduces extra concerns, costs and (perhaps) delays. And even if these FR wraps or coatings could work, one has to rely on the conscientiousness and common sense of the contractor and his crew. Otherwise, they might "screw up" and the building inspector and/or fire marshall will not pass the system (even though it is, in theory, permissible under the code).

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Lombardi is familiar with Blazemaster for water sprinkler systems, and he has recommended it in recent building designs. However, his customers are now coming back and claiming that it costs more than conventional carbon steel systems. The recent rise in resin prices is again partly responsible. In other cases workmen have become sick from solvent welding in confined spaces, and work time has been lost.

Lombardi suggests that the key to PVC or ABS penetrating DWV piping in multi-story fire-rated buildings is to improve the inherent fire resistance and smoke emission rate of the plastic material. Burton & Van Houlten has been innovative in the past in designing smoke escape routes for their buildings, and they are reluctant to switch now to a material that could jeopardize these potential gains. One can design around the other problems of plastics--noise, expansion/contraction, etc.--but mechanical engineering firms are basically conservative. They may accommodate their customers in exploring possible cost-cutting programs in non-critical parts of the building, but they will not compromise on safety because that is their responsibility. "The first company to develop a non-combustible, processable plastic will really strike it rich. But we'll still wait for someone else to spec it in and test it before we will make such a move."

Kolff & Associates

I called an acquaintance from my hometown (New Canaan, Connecticut), Albert Kolff, who is the principle in an architectural firm that designs new hospital buildings and hospital extensions. Kolff indicated that whereas the specification of materials for DWV pipe for hospitals is in the jurisdiction of the mechanical engineers, the architects such as himself have to review such recommendations since they are legally liable for the adequacy of the materials and parts incorporated into these buildings. And he is aware of several of the dimensions of the plastics versus metal issue in DWV piping (i.e., structural strength, flame spread and smoke emissions, the need for hangers and supports depending on material, putative cost savings, etc.).

Kolff mentioned that in the last two hospital plans he has either prepared or contributed to (particularly for hospital kitchen facilities, including plumbing) the issue of plastics replacing the conventional cast iron has come up. And the hospital design professionals are universally in favor of plastics to capture the potential cost savings in view of the increasingly severe cost limits that the hospitals face in their building programs. Yet whether due to the conservatism of the building inspectors in the New York/

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Connecticut area or that of the hospital review board, the decision was made in each case to go with conventional cast iron DWV piping.

Kolff suggests that the plastic pipe manufacturers will have to develop better inherent flame resistance and lower smoke emission rates in the ABS and PVC utilized. I mentioned the pipe wrap technology and Kolff thought that it would be ideal if in fact it delivered the 2-3 hour fire rating required. He also asked whether there would be resistance to plastic DWV piping and other piping from an environmental standpoint when such systems have to be repaired or replaced at the end of the building's useful life. I told him that the ecological concern over plastics recycling is certainly real, but it can't logically extend to DWV piping systems in non-residential construction, particularly since these plastic pipes won't be pulled out of service until many years from now when plastics (and all other materials) recycling will be a high-volume, viable business.

Kolff recommended that I call another architectural firm in Connecticut--Stecker, Lebau, Arneill and McManus of Glastonbury, which is involved in hospital design work. I spoke to the president, Bruce Arneill, and he directed me to two local mechanical engineering firms--Van Zehm, Heywood and Shadford of West Hartford and Burton & Van Houlten of Hartford--as well as a New York City-based firm, Sysk & Hennessey.

<u>James Ursini</u>

I spoke with Arthur Spose at James Ursini, a leading Connecticut building contractor based in New Haven. He stated that in the context of the modern fire codes there is little to no use of plastic piping (DWV or other) in high-rise buildings in the Northeast. There was one building recently that Ursini built where plastic DWV pipe was installed in the garage under the building, but that was permissible under the code.

Spose said that the real problem with plastic DWV pipe is that it has to be fire-stopped whenever it penetrates a floor. You can encase it in a fire-rated shaft, "but why bother" when cast iron pipe is available. He believes that plastic pipe is very cost-effective in residential buildings, but it has virtually no scope in high-rise office blocks. That is particularly the case in New York City where they insist on cast iron with lead joints. "You won't find plastic pipe in New York City buildings."

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Van Zehm, Heywood & Shadford

I called Van Zehm, Heywood & Shadford, a mechanical engineering firm in West Hartford, Connecticut, and spoke with Bill McKone, one of the firm's mechanical engineering designers. He indicated that the company is one of the largest Connecticut-based engineering firms, and they have done design work for the state's universitites (e.g., Yale and Wellesley) and insurance companies.

McKone claims that he and his colleagues at Van Zehm seldom spec in (and seldom are told by clients to spec in) plastic DWV piping. It is used occasionally in some 1-story building projects, but in the smaller multi-story non-residential buildings they tend to use copper DWV piping and then in the larger multi-story buildings they use cast iron. As a rule of thumb, according to McKone, they use copper piping up to 3" pipe diameter requirements and then cast iron is used in the larger diameter pipe. The cast iron is considerably stronger and cheaper. Van Zehm has standard specs for DWV pipe--that is, no hub cast iron above ground and hubbed units below ground.

McKone indicated that there is no prohibition on using plastic DWV piping under the current Connecticut building code (basically the BOCA code with modifications). The architects and the mechanical engineering community simply don't want to deviate from the conventional cast iron. McKone states emphatically that PVC DWV piping is always cheaper, but set against that advantage the PVC or ABS piping

1) is more susceptible to flame,
2) emits more smoke in a fire situation,
3) requires more hangers and supports, and
4) is much noisier.

Apropos (4) above, McKone claims to have experienced plastic DWV pipe in low-cost apartment complexes, and he can attest to the disturbing noises from the plastic pipe system, particularly for the first-floor occupants. And that is the only context where McKone sees plastic DWV piping used these days--in low-cost, speculative single- and multi-story residential buildings.

PLUMBERS: RECENT STRENGTH OF THE PLUMBERS' UNION

To the extent that the issue of plastics versus metals in high-rise building construction rests in large part on the ability of the plumbers to defend their position installing the more labor-intensive cast iron pipe systems, it is worthwhile to at least briefly take

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note of the strength of the competition facing the plastics industry. The union to which virtually all the plumbers and pipefitters belong is the United Association of Journeymen & Apprentices of the Plumbing & Pipe Fitting Industry of the United States and Canada (UA). Over the past 15 years the ability of the building-related trade unions to defend their jobs and their work rules has been eroded as contractors instituted more and more labor-saving materials, equipment and practices in their construction programs. Yet, interestingly, the UA has suffered least of all during this period of construction employment retrenchment.

As we can see in Table 29 below, whereas the number of union steelworkers has fallen by 53% over the period 1975-1987 and the number of union bricklayers has fallen by 41%, the number of union plumbers and pipefitters has only declined by 3½% and they remain 220,000 strong.

TABLE 29

TRENDS IN MEMBERSHIP OF BUILDING-RELATED TRADE UNIONS, 1975-1987
(000)

Trade Union	1975	1987	Cum % Change
Brick layers	143	84	-41
Carpenters	712	609	-14
Electrical workers	856	765	-11
Ironworkers	160	122	-24
Painters	160	128	-20
Plumbing & pipefitting	228	220	-3½
Steelworkers	1062	494	-53

Source: U.S. Department of Commerce, Statistical Abstract of the United States 1989.

Thus, the plastic pipe industry has to realize in deciding whether to devote additional resources to the battle for greater share of the high-rise DWV pipe market that the plumbers are in a relatively strong position economically. And all our consultations with code administrators and construction industry players suggest that the

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plumbers have been diligent in participating at every level of local and national government where their union rules might be threatened (i.e., local and national code-writing bodies). The plastic pipe industry would have to be prepared to devote as much time and manpower to the "cause" across the country at the local and state level to mobilize code changes that permit plastics to at least compete for the mechanical engineers' preferences.

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RECENT DEVELOPMENTS WITH IMPLICATIONS FOR PLASTICS IN DWV PIPE IN FIRE-RATED BUILDINGS

THE ADVENT OF FIRE-STOPPING DEVICES

PROSET SYSTEMS

I spoke with Ken Cornwell who is the president of Proset Systems of Atlantic, Georgia. Proset manufactures firestops--that is, water distribution and DWV pipe couplings for floor openings and stacks that eliminate the spread of fire through the metal or plastic pipe system. They can be used with copper, steel, cast iron, ABS and PVC pipe, in poured concrete floors and fire-rated walls. The Proset device meets the following fire tests and codes:

Fire Tests

ASTM E814-83
UL 1479
CAN4-S115-M85

Codes

BOCA
ICBO
IAPMO
SBCCI
CSA
NSF

Cornwell claims that the Firestop device was first patented in 1980 and there were subsequent patented improvements. The Proset system (System C) for plastic pipe penetrations, which is referred to as a "code red stack fitting", incorporates a cast iron tapered plug that is held inside the branch of a wye fitting by means of a temperature-sensitive polypropylene harness. When the temperature reaches 250°F, the harness releases the plug into the base of the stack, sealing up the opening and preventing fire/smoke transmissions through the pipework. Ceramic fiber insulation is used to plug voids in the system when installed. Elastomeric couplings are used at the pipe/fitting joint. Altogether, the system provides up to 4 hours fire rating.

The advantages of Firestop, according to the company literature, are it

1) provides a secure, waterproof, smokeproof, fire-rated floor/wall penetration,

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2) allows for normal expansion and contraction of the plastic pipe,
3) eliminates the need for riser clamps and hangers,
4) vents out toxic fumes,
5) reduces noise,
6) eliminates the voids, and
7) installs easily and costs less.

Cornwell claims that the Firestop concept is now well-recognized in residential and non-residential building. When I asked about recent construction projects using Firestop devices, he mentioned the Marriott Hotel chain and other (largely Southern) projects. We attach in Table 30 following a list of recent Proset programs.

TABLE 30

RECENT PROSET JOBS

	Name	Location	Contractor
Hotels[a]	The Marriott Marquis 1650 guest rooms 54 story	Atlanta, GA Largest hotel in Georgia	Economy Mechanical Tucker, GA
	The Disney World Marriott 1507 guest rooms 28 story	Orlando, FL Largest hotel in Florida	Inscho-Kirlin Fort Lauderdale, FL
	Nashville Stouffer Convention Hotel 780 guest rooms 31 story	Nashville, TN Largest hotel in Tennessee	Comfort Control Nashville, TN
	Stouffers Gallery Hotel 600 guest rooms 12 story	Baltimore, MD Largest hotel in Maryland	Pool & Kent Co.
	The Grand Cyprus Hyatt	Orlando, FL	ANUC Inc.
	The Radisson Hotel	Myrtle Beach, SC	Davis Mechanical
	Convention Center Hyatt	Washington, DC	John J. Kirlin
	The Ritz Carlton	Atlanta, GA	B & W Mechanical
Office Buildings			
	IBM Tower	Atlanta, GA	McKenneys, Inc.
	One Kansas City Place	Kansas City, MO	Mid-West Mechanical
	Martin Marietta	Avon Park, FL	Wesco, Inc.
	Lincoln Towers	Miami, FL	Sam Bloom Plumbers

Continued....

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Hospitals	Orlando Regional Hospital	Orlando, FL	Economy Mechanical
	St. Marys Hospital	Grand Junction, CO	Summit Mechanical
	Johns Hopkins Hospital	Baltimore, MD	J.A. Zimmer
	Humana Hospital	St. Petersburg, FL	Reliable Plumbing
Prisons	Broward County Jail	Ft. Lauderdale, FL	Seaboard Plumbing
	Cobb County Jail	Cobb County, GA	M & E Mechanical
	Lapeer County Jail	Lapeer, MI	D & L Mechanical
	Collier County Jail	Naples, FL	B & I Contractors
Apartments	Concorde Towers	Atlanta, GA	Wesco Mechanical
	South Hampton	Myrtle Beach, SC	Davis Mechanical
	The Ocean Club	Isle of Palms, SC	Stasco Mechanical
	The Plaza Venetia	Miami, FL	Sam Bloom Plumbers

a Proset devices have been installed in over 60,000 hotel rooms - August, 1986.

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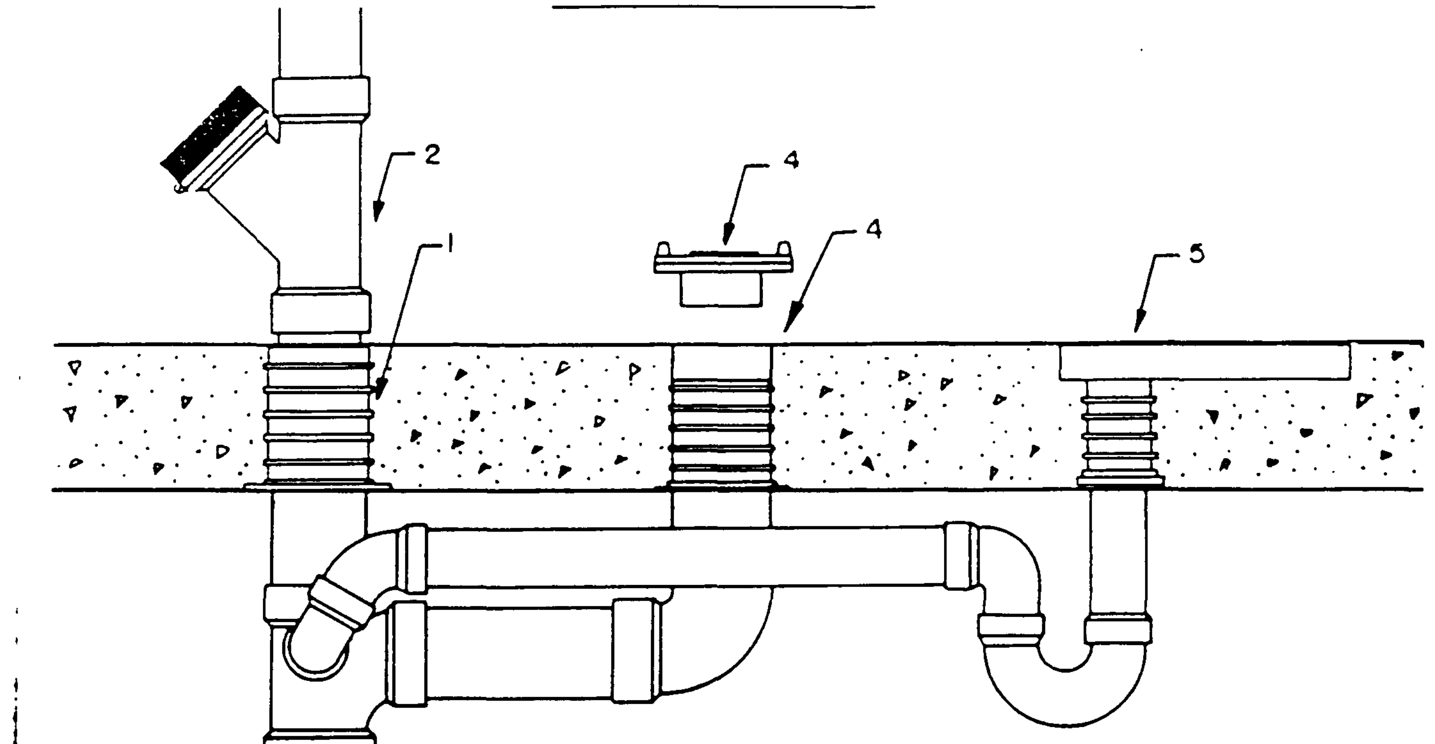
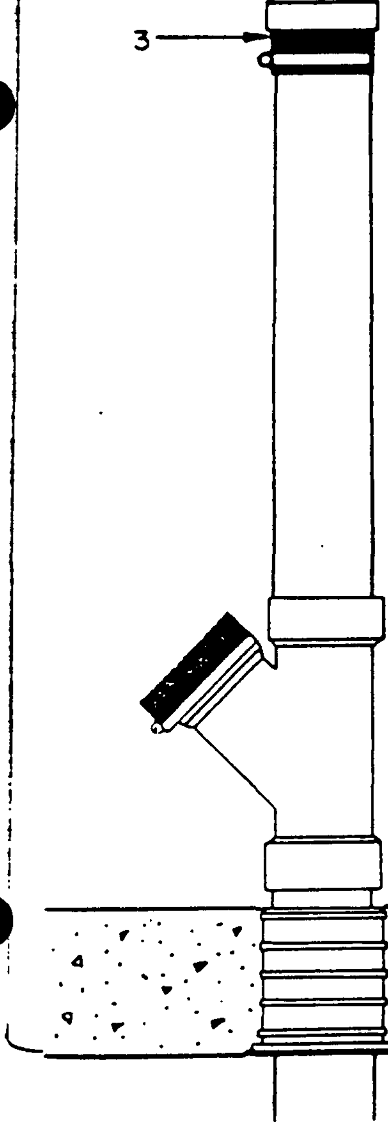
FIGURE 5

A SCHEMATIC OF THE PROSET FIRESTOPPING DEVICE PLASTIC INSTALLATION





1. ***Firestop Coupling*** - U.L. Classified PVC plastic coupling "sleeve." Installed before the concrete pour; permanently embedded in the slab. ***Code Red Stack Fitting*** is inserted into the ***Firestop Coupling*** from above, plastic pipe is solvent welded to the ***Firestop Coupling*** from below.

2. ***Code Red Stack Fitting*** - U.L. Classified firestop device permits use of plastic DWV in fire-rated construction.

3. ***E-Z Flex Coupling*** - Elastomeric PVC coupling used for pipe insertion, to accommodate pipe expansion/contraction, and acts as a sound absorber to reduce pipe noise.

4. ***Closet Stub-in*** - U.L. Classified firestop device provides fire-rated closet fixture opening. Closet flange is included to be installed after the pour.

5. ***Tub Box*** - U.L. Classified firestop device provides fire-rated bathtub drain opening.

NOTE: ***Code Red Stack Fitting*** is not required at penetrations through the ground floor slab or through the roof

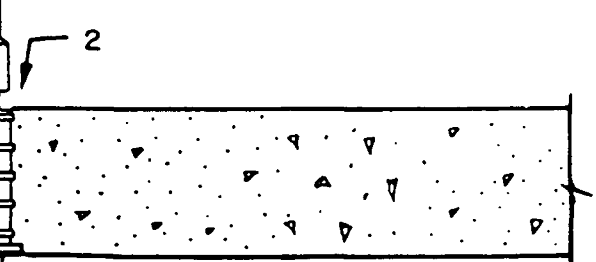


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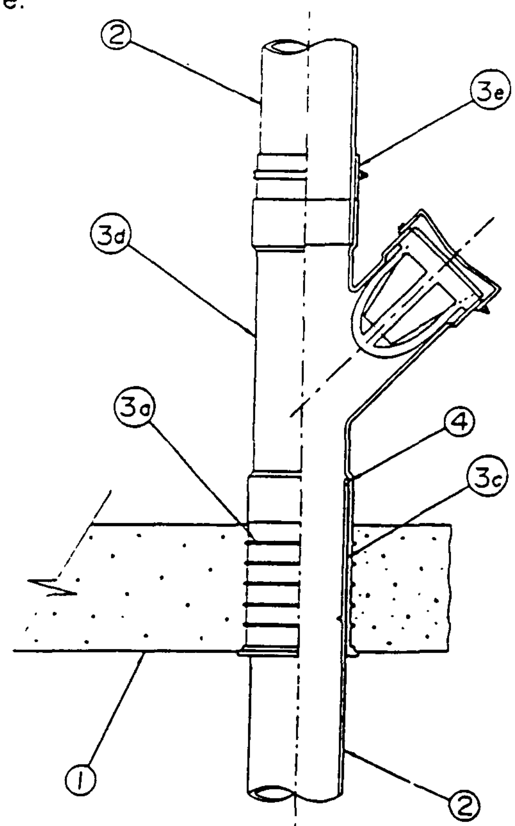
FIGURE 6

PROSET SYSTEMS' CODE RED STACK FITTING FOR PLASTIC DWV

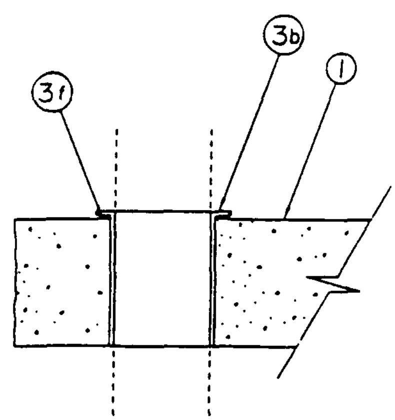
The 2" -3" -4" & 6" Code Red Stack Fitting is a two - part assembly consisting of a coupling cut flush with the concrete floor and a wye fitting with a plastic/cast iron liner extension pipe that solvent welds into the top of coupling. A polyethylene harness melts out & causes a cast iron plug to drop & close the opening during a fire.

ProSet U.L. classified products are listed by Part No. because they are Devices not Systems.

I.D. Nos.	PROSET Part Nos. 2" & 6"
3a	P25458 - P65458
3b	P25558 - P65558
3d	CP25900 - CP65900
3e	P25470 - P65470



CAST-IN-PLACE DETAIL



RETROFIT DETAIL

1. Concrete or Precast Floor
2. PVC or ABS Sch. 40 Pipe
3a. Cast-In Place Coupling
3b. *Cored Hole Coupling
3c. Plastic to C.I. pipe
3d. Code Red Wye Fitting
3e. E-Z Flex Coupling
3f. Type 81155 Adhesive Caulk
4. Plastic Retainer Ring

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ASTM E-814 Fire Rating 3 hrs. in 8" & 2 hrs. in 4" Concrete Slab.

As for the typical cost of using the Proset firestopping system for plastic DWV pipe, the following prices were quoted by Proset Systems as of November 1988 for key components of the system:

Code Red firestop (4")	$25.95
Cast-in Code Red coupling (4")	8.25
E-Z flex coupling (4")	3.95
	$38.15
Cast-in water closet stub (4")	$12.20
Cast-in shower drain (2")	$20.85

Cornwell admitted that the Proset device is expensive on its own, but it allows the plastic pipe systems to be specified with code approval and the total cost of water distribution and DWV pipe systems are lower than those with cast iron. In Florida most of the Proset jobs have been with PVC pipe since ABS pipe is not allowed in Florida. In Georgia, the Fulton County Stadium in Atlanta, which has had 2 separate cast iron DWV pipe systems installed and then ripped out due to pipe failure from corrosion, has installed plastic DWV pipe with Proset connectors. Cornwell sees good growth in these types of applications in the future.

MSP PRODUCTS

I spoke with Jerold Harbeke who is the president of MSP Products of Lake Worth, Florida, a company set up in 1989. Harbeke took a 3M patented material--a rubber-based material that expands up to 10 times its original size when exposed to temperatures of 250°F or higher and will not burn itself--and incorporated it into a patented firestopping device for pipework. The device is UL-tested and approved and is listed in the 1990 UL Fire Resistance Directory. The MSP Products device, in effect, competes with the Proset firestopping device that uses a cast iron plug as the firestopping mechanism. Harbeke claims that the Proset device has had problems at the point of installation when the plastic harness holding the plug fails (e.g., through rough handling) and plugs the Code Red fitting prematurely.

Harbeke claims that his patented product is being used in Florida construction projects and elsewhere, although he wouldn't provide details. He also refused to send me a catalogue of his products, claiming that I could get this information from the UL 1990 Fire Resistance Directory. He claims that his fittings are being used in conjunction with PVC pipe systems in Florida and with ABS pipe systems in the Northern states where ABS withstands better the cold weather extremes.

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THE PROLIFERATION OF SPRINKLER SYSTEMS

One of the most important fire safety developments of the 1980s is the steady introduction of fire sprinkler systems in both residential and non-residential buildings. The national model codes have largely lagged behind this trend because, again, the code writers are only aiming for minimum levels of fire safety. The builders are also (as a group) against this concept, at least in residential buildings. They contend that it makes eminently good sense in a high-rise building where the fire truck hoses can't reach burning upper floors, but in low-rise residential and non-residential buildings they resist these systems because they add a lot of costs with only small, questionable gains in fire protection and occupant safety.

Yet there is a growing number of communities that now require fire sprinkler systems in new houses such as

- -Greenburgh, NY and other Westchester county towns
- -San Clemente, CA
- -Cobb County, GA
- -Prince George's and Montgomery Counties, MD

and dozens of others are apparently weighing the cost/benefit of residential sprinkler systems.

Most people regard fire sprinkler systems as appropriate to non-residential, not residential, buildings. However, of the 6,000 people who die each year in fires, 80% are in house fires. The introduction of smoke alarms in the early 1980s brought this figure down, but then the total has stalled at this level for the past decade. Groups like the NFPA believe that fire sprinklers in homes will reduce it further.

Fire officials point out that homes burn more quickly today; whereas flashover in a typical house used to take 8-10 minutes, it now takes 3-5 minutes. Increased plastics in electrical devices and wiring, wallpaper, furniture padding and carpeting aren't totally responsible, but they have accelerated this trend.

In New York City sprinklers are not required in one-and two-family houses or town houses, but they are required in the halls of multiple dwellings where there are no secondary exits such as fire escapes and fire stairways. They are also required in townhouses that have been divided into apartments. They are also mandatory in New York City hotels.

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Interestingly, the sprinkler systems represent a growth market for pipe, and plastics can take its share of this application. Even recent NFPA code changes permit the use of plastic pipe in lieu of steel/cast iron pipe. The cost of installation is generally $1-2/sq. ft., so a medium-size new house of 1,850 sq. ft. would involve the expenditure of $1,850 to $3,700 to the builder and $2,000-4,000 to the buyer. House builders resist such extra costs, arguing that the vast majority of fire deaths occur in the older housing stock and installing fire sprinkler systems is a set-back to affordable housing. They prefer to address the flammability of furnishings, rather than the possibly heavy-handed approach of requiring fire sprinklers in every home.

Equally interestingly, in Cobb County, Georgia the fire marshall has recommended to the local building authorities that builders be allowed to use less expensive materials if they agree to install sprinklers. For example, it is conceivable that plastic piping of the various types (DWV, water supply, sprinkler systems) could be used if sprinklers were put in place.

Two recent fires have advanced the cause of installing sprinkler systems in high-rise buildings which would enhance the prospects for plastic piping of all sorts in these buildings. In late 1989 a fire in an Atlanta, Georgia 10-story office building led to the deaths of five people. The city council noted that the building did not have a sprinkler system and rapidly approved a measure requiring such systems in certain existing and all new buildings by December 1994. All commercial buildings of over 5 stories and certain apartment buildings and hotels would be affected. The city's Finance Department is investigating the feasibility of offering tax breaks to builders to offset some of the costs of the required retrofitting.

In Tennessee there was a fire at an 11-story retirement home in Johnson City where 16 people died, most of them from smoke inhalation. The local fire officials claimed that many of these elderly people might have survived if the building had been equipped with a sprinkler system. Also, the 102-ft. long fire department vehicle ladders were unable to reach the top two floors.

In fact, the Tennessee state building code had been revised in 1979 to require sprinklers in all new and retrofitted high-rise buildings. However, the retirement home had been renovated and was zoned as an apartment house just before the 1979 ordinance was passed. So it was technically in compliance. The state of Tennessee is now considering mandating sprinkler systems in all high-rise retirement homes. At the moment, for example, 10 of Nashville's 25 high-rise retirement homes lack sprinkler systems, and these will be affected by code revisions.

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LESSONS FROM OTHER MARKETS WHERE FIRE RESISTANCE IS A KEY TO PLASTICS VERSUS METALS COMPETITION

There are, of course, many markets where plastics compete against metals, and one of the highest hurdles for plastics to overcome is flammability, smoke emission and other thermal properties. We select here two with what we feel are striking parallels to the DWV/soil pipe business--one drawn from within the building industry annals and another from a completely different pipe sub-market.

THE ELECTRICAL CONDUIT MARKET

The evolution of acceptance of plastic DWV pipe in low-rise and high-rise buildings is, to some extent, following the pattern of acceptance of plastic conduit for electrical wiring in buildings. Up through 1980 the only material approved for electrical wiring conduit was steel tubing. In 1980 a major manufacturer of steel electrical conduit (Allied Tube & Conduit Corporation of Harvey, Illinois) responded to the imminent threat of a switch to plastic (PVC) conduit by packing an NFPA meeting and defeating a proposal to allow plastic conduit in the forthcoming edition of the National Electrical Code (NEC). A plastic tubing manufacturer, Carlon of Cleveland, Ohio sued Allied and the NFPA on antitrust grounds and won a judgment in the courts. In 1987 the Supreme Court ruled in Carlon's favor and upheld an $11 million jury award. Plastic electrical conduit was approved in the 1984 edition of the NEC, but only for use in buildings of three floors or less. It was only approved for use in all buildings in the 1987 edition of the NEC.

We called Carlon and spoke with Mark Buck, a vice president at the company. He declined to comment on this case until we could provide a written indication of who we were (at BCC) and what our research interests were. We wrote such a letter, but we have yet to hear from Mr. Buck.

FR PROTECTION OF PLASTIC PIPES IN OIL RIGS

The plastic DWV pipe companies can also derive some lessons and encouragement from the experience that the European plastic pipe manufacturers have gained promoting their products to the mechanical contractors involved in the construction and maintenance of North Sea-based oil rigs. The primary regulatory authorities governing material selection for components to be installed on these rigs are Norwegian and British. The Norwegian and British regulations/ standards for pipe used in offshore oil installations have always been predicated on the use of steel, and they have all traditionally

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prohibited the use of "combustible" materials. However, despite these restrictions, these regulatory agencies have recently been granting "dispensations" from the prohibitions on combustible materials to permit plastics (specifically fiber-reinforced plastic pipe) to be used in actual offshore applications (e.g., fire water systems, fluid distribution systems, engine cooling systems, and other low-pressure pipe applications).

In effect, the Norwegian and British regulatory authorities both recognize that the existing standards based on the conventional performance of steel are out-dated, and they represent an explicit constraint on the competition from alternative materials such as plastics. They also are convinced that steel pipe has disadvantages --corrosion, stress cracking, high maintenance expenses--that plastic pipe can alleviate. Critically, the Norwegian and British authorities have become persuaded of the idea that with appropriate integral and/or external means of fire protection there is an opportunity to provide superior <u>total</u> safety performance relative to steel pipe. These authorities are involved today in extensive testing of plastic pipe on the rigs and are considering extending the scope of these tests to other rig parts (e.g., panels, structures, doors, etc. on the accommodation modules).

The means being explored to fire-protect plastic (FRP) pipe on these oil rigs are varied--namely,

- -FR additive packages compounded into the resin
- -epoxy-based intumescent coatings
- -latex-based intumescent coatings
- -ceramic or glass fiber wrappings
- -combinations of the above

Many of these methods can provide the required 1-hour fire protection. On filled water pipes, meeting this standard is fairly straightforward; on empty pipes in 1-hour fire rating is much more difficult to achieve. And (as in the case of plastics DWV pipe) <u>all</u> of these methods add to costs (some of them are very expensive), they add to labor costs, and they reduce the plastics advantage of light weight relative to steel pipe.

THE SITUATION IN CANADA

In Canada the National Research Council based in Toronto issues the National Building Code and then the provinces largely adopt this code unchanged. Like the U.S. model codes, there are restrictions in the NBC on the use of combustible piping materials in high-rise buildings, so plastics and cast iron tend to share the low-rise building DWV pipe market whereas cast iron dominates in the high-rise building segment.

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Canron is one of the leading Canadian manufacturers of plastic pipe, and I spoke with Brian Peto who is the Marketing Manager. He was cooperative, but disarmingly disorganized as Canron is in the middle of divesting itself of several of its pipe product lines (ductile steel and concrete), and most of Peto's files seemed to be arrayed around his desk on the floor!

Peto indicated that historically Canada is an ABS DWV pipe market since this was the first resin to be used when the building code opened up to plastic pipe. Canron produces ABS pipe exclusively, although some of its competitors in Canada (e.g., Scepter Manufacturing of Toronto) manufacture PVC pipe that they are promoting for DWV applications.

Peto says that the same restrictions on plastic DWV (and other) pipe in high-rise buildings apply in Canada as in the U.S. However, he feels that the relatively new firestopping devices may be able to allow the plastic pipe manufacturers to circumvent those restrictions. He cited several U.S. and Canadian companies that are active in firestopping devices such as

1) 3M of St. Paul, MN,
2) Fyre Sleeve of Burnaby, British Columbia,
3) Dow-Corning of Mississauga, Ontario.

He hadn't heard of Proset Systems, but he has heard that Scepter is working with B.F. Goodrich to promote the use of firestops to qualify PVC for high-rise DWV pipe.

Peto was not very insightful when it came to the likely trend of plastics in high-rise DWV pipe. He just assumes that "it will take time".

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APPENDIX A

LIST OF OFFICIALS AT ORGANIZATIONS, GOVERNMENT AGENCIES AND COMPANIES CONSULTED

Organizations	Official(s)	Telephone #
ASME	Christine Krupinski Cal Gomez (Engineering)	212-705-7722
CISPI	Bill LeVan (Executive VP)	615-892-0137
IAPMO	John Meecham (Engineering)	714-595-8449
ICBO	John Trau (VP, Codes Engineering)	213-699-0541
NAPD	Carol Wagner (Director)	913-268-6273
NFPA	Joe Jardin (Life Safety Engineer)	617-770-3000
PPFA	Carol Asselmeier (Director)	708-858-6540
SBCCI	Doug Connell (Engineer, Plan Review)	404-325-3120
UA	Maryann Coyle (Archivist)	202-628-5823

Government Agencies	Official(s)	Telephone #
Chicago City Council	Daniel Weil (Building Inspector)	312-744-3400
New York City Commissioner of Buildings	Murray Lipstein (Chief Plumbing Inspector)	212-312-8600
Norwalk City Building Department	Marty Spahr (Sanitation Department)	203-854-7755
U.S. Department of Commerce	Patrick McAuley (Construction)	202-377-0132
U.S. Federal Trade Commission	Richard Duke (Economist)	202-326-2222

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APPENDIX A (Cont'd)

Companies	Official(s)	Telephone #
Alcan	Bill Roberts (DWV Pipe Product Manager)	404-396-1364
American Brass & Iron Foundry	Mike Chacon (Marketing Manager)	415-632-3467
Anaheim Foundry	Joe Attalla (Sales Administrator)	714-870-9000
Brady & Anglin	Lionel Grindstaff (Associate)	404-325-3120
Bristolpipe	John Minelli (Sales/Marketing)	219-848-4402
Burton & Van Houlton	Gary Lombardi (Senior Plumbing Engineer)	203-236-2365
Carlon Electrical Science	Mark Buck (Division VP)	216-831-4000
Canron	Brian Peto (Marketing Manager)	416-742-5334
CertainTeed	John Cawkins (Sales/Marketing)	215-341-6820
Charlotte Pipe	Alan Biggers (Senior VP)	704-372-5030
Colonial Engineering	Bruce Packard (Engineering)	407-464-4100
Eastern Foundry	Stan Bloom (VP, Sales/Marketing)	215-367-2153
Eslon Thermoplastics	Tom Foster (Dir. of Sales/Marketing)	704-889-2431
F.W. Dodge	Secretary (Publications office)	212-512-2000
Griffin Pipe	Wayne Hinson & Jim Sales (Sales/Marketing)	804-845-8021
James Ursini, Inc.	Arthur Spose (Vice President)	203-628-5823
Kolff & Associates	Albert Kolff (Principal)	203-966-1552

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APPENDIX A (Cont'd)

Companies	Official(s)	Telephone #
LCP	Bob Watson & Johnnie Hall (Engineering & Sales/Mark.)	201-225-4840
MSP	Jerold Harbeke (President)	407-586-7871
R.S. Means	Melvin Mossman (Engineer)	617-585-7880
Proset Systems	Ken Cornwell (President)	404-454-8427
Slocomb Pipe	Bob Burney (Engineer)	205-886-2353
Spartan Plastics	Bill Schreiber (VP, Sales)	714-682-3777
Tyler Pipe	Boyd Tatum (Manager of Soil Pipe Sales)	214-882-5511
U.S. Pipe	Bob Gruter (Sales Manager, Soil Pipe)	615-752-3700
Universal Cast Iron	Vince Berrey (Sales Manager)	
Van Zehm, Heyward & Shadford	Bill McKone (Mechanical Eng. Design)	203-236-5426

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APPENDIX B

STANDARDS-SETTING ORGANIZATIONS REFERENCED IN THE BOCA NATIONAL BUILDING CODE 1990

AA	Aluminum Association Suite 300 900 19th Street NW Washington, DC 20006
AAMA	American Architectural Manufacturers Association 2700 River Road, Suite 118 Des Plaines, IL 60018
AASHTO	American Association of State Highway and Transportation Officials Suite 225 444 North Capitol Washington, DC 20001
ACI	American Concrete Institute P.O. Box 19150 Detroit, MI 48219
AHA	American Hardboard Association 520 North Hicks Road Palatine, IL 60067
AISC	American Institute of Steel Construction, Inc. The Wrigley Building Eighth Floor 400 North Michigan Avenue Chicago, IL 60611
AISE	Association of Iron and Steel Engineers Suite 2350 Three Gateway Center Pittsburgh, PA 15222
ASIS	American Iron and Steel Institute Suite 300 1133 15th Street, N.W. Washington, DC 20005
AITC	American Institute of Timber Construction 11818 S.E. Mill Plain Blvd. Suite 415 Vancouver, WA 98684

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ANSI	American National Standards Institute 1430 Broadway New York, NY 10018
APA	American Plywood Association 7011 S. 19th St. P.O. Box 11700 Tacoma, WA 98411-0700
ASCE	American Society of Civil Engineers 345 East 47th Street New York, NY 10017
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 1791 Tullie Circle, NE Atlanta, GA 30329-2305
ASME	American Society of Mechanical Engineers 345 East 47th Street New York, NY 10017
ASTM	American Society for Testing and Materials 1916 Race Street Philadelphia, PA 19103-1187
AWPA	American Wood-Preservers' Association P.O. Box 849 Stevensville, MD 21666
AWPB	American Wood Preservers Bureau P.O. Box 5283 Springfield, VA 22150
AWS	American Welding Society 550 N.W. LeJeune Road P.O. Box 351040 Miami, FL 33135
BIA	Brick Institute of America 11490 Commerce Park Drive Reston, VA 22091
BOCA	Building Officials and Code Administrators International 4051 West Flossmoor Road Country Club Hills, IL 60478-5795

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APPENDIX B (Cont'd)

CABO	Council of American Building Officials 5205 Leesburg Pike Suite 201 Falls Church, VA 22041
CGSB	Canadian General Standards Board Technical Information Unit Ottawa, Canada K1A 1G6
CMAA	Crane Manufacturers Association of America Suite 201 8720 Red Oak Blvd. Charlotte, NC 28217
CMIFC	Concrete and Masonry Industry Firesafety Committee 5420 Old Orchard Road Skokie, IL 60077-1083
CPSC	Consumer Product Safety Commission Office of the Secretary Washington, DC 20207
CRSI	Concrete Reinforcing Steel Institute 933 North Plum Grove Road Schaumburg, IL 60173-4758
DOC	United States Department of Commerce National Institute of Standards and Technology Gaithersburg, MD 20899
EIA	Electronics Industries Association 2001 Eye (I) Street NW Washington, DC 20006
FM	Factory Mutual Standards Laboratories Department 1151 Boston Providence Turnpike Norwood, MA 02062
GA	Gypsum Association 810 First Street NE, #510 Washington, DC 20002
HPMA	Hardwood Plywood Manufacturers Association 1825 Michael Faraday Drive P.O. Box 2789 Reston, VA 22090

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APPENDIX B (Cont'd)

MBMA	Metal Building Manufacturers Association 1230 Keith Building Cleveland, OH 44115-2180
NCMA	National Concrete Masonry Association 2302 Horse Pen Road P.O. Box 781 Herndon, VA 22070-0781
NFiPA	National Fire Protection Association Batterymarch Park Quincy, MA 02269
NFoPA	National Forest Products Association 1250 Connecticut Ave. NW, Suite 200 Washington, DC 20036
PCI	Precast/Prestressed Concrete Institute 175 West Jackson Blvd. Chicago, IL 60604
RCSHSB	Red Cedar Shingle & Handsplit Shake Bureau Suite 275 515 116th Ave., N.E. Bellevue, WA 98004
RMA	Rubber Manufacturers Association 1400 K Street, N.W. Washington, DC 20005
SJI	Steel Joist Institute Suite A 1205 48th Avenue North Myrtle Beach, SC 29577
SPRI	Single Ply Roofing Institute 104 Wilmont Road Suite 201 Deerfield, IL 60015-5195
TFS	Texas Forest Service Forest Products Laboratory P.O. Box 310 Lufkin, TX 75902-0310

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TPI	Truss Plate Institute 583 D'Onofrio Drive Suite 200 Madison, WI 53719
UL	Underwriters Laboratories Inc. 333 Pfingsten Road Northbrook, IL 60062-2096

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