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SURVEY OF PLASTICS PROBLEMS IN THE NEW ZEALAND BUILDING INDUSTRY

N. L. Trebilco

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PREFACE

This survey is part of BRANZ's ongoing research into the durability of building materials. The results from this survey will be used to help decide those areas of plastics use that require further research.

ACKNOWLEDGEMENTS

The author thanks all questionnaire respondents and also Sarah Harper, Applied Maths Division, DSIR for her assistance with the statistical design and analysis of the returned questionnaires. Thanks are also due to Glenda Hawthorn for keyboard entry of the questionnaire returns. This work was funded by the Building Research Levy and the Foundation for Research Science and Technology from the Public Good Science Fund.

This report is intended primarily for researchers, manufacturers, designers and specifiers.

SURVEY OF PLASTICS PROBLEMS IN THE NEW ZEALAND BUILDING INDUSTRY

BRANZ Study Report SR47 N.L. Trebilco

REFERENCE

Trebilco, N.L. 1992. Survey of plastics problems in the New Zealand building industry. Building Research Association of New Zealand, BRANZ Study Report SR47, Judgeford, New Zealand.

KEYWORDS

From Construction Industry Thesaurus - BRANZ Edition: Acetal, Builders, Buildings, Construction Industry, Designers, Durability, Failure, Glazing, Pipes, Plastics, Plumbers, Plumbing, Polybutylene, Polycarbonates, PVC, Statistical Data, Surveys.

ABSTRACT

A building industry-wide survey was carried out using a looseleaf questionnaire in BRANZ magazine "Build" to identify the relative incidence of problems being experienced with plastics in New Zealand buildings. Main types of plastics use surveyed were piping, vapour barriers, claddings, glazing and flooring. The majority of failures were in plastic piping followed by plastic glazing. Faulty installation and faulty product design or manufacturing defects were identified by respondents as being responsible for most piping/piping fitting failures. Poor weatherability of (rigid clear) PVC and polycarbonate sheeting was the cause of most glazing failures. The need for further study on the incidence of polybutylene (and acetal fitting) pipe system failures and on the durability of polycarbonate glazing is indicated.

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1.0 INTRODUCTION

A substantial amount of plastic is used in buildings. From NZ Department of Statistics figures (Gunter, 1989) the factory value of plastics produced in NZ in the March 1987 year was $997 million (also Stirling and Mitchell, 1988). From overseas figures it is estimated that one fifth of this production will go into building and construction (i.e., about $200 million). This excludes plastics which may be used in buildings but are not part of the building fabric e.g. appliances and soft furnishings.

Previous work carried out by BRANZ on plastics used in building includes a review of the durability of building plastics (Sharman and van Gosliga, 1989), a report on some problems with plastics durability in New Zealand (Sharman, 1987) and an investigation of plasticiser migration from PVC cable sheathing (Bennett, 1987).

A previous survey considered some of the problems associated with plastics generally from a manufacturing view (Stirling and Mitchell, 1988). That survey suggested that there were two areas worthy of study - the mechanical failure mechanisms of plastics and the chemistry of polymer degradation in relation to processing problems.

This present survey was initiated to help establish those types of plastics use in buildings with the greatest incidence of problems. Responses from the survey were to be collated and form part of the basis for deciding future research work.

2.0 QUESTIONNAIRE RESPONDENTS

A questionnaire on 'Building Plastics' was distributed to the building industry via the BRANZ 'BUILD' magazine. The questionnaire went out to a wide cross-section of the building industry including builders, subcontractors, plumbers/drainlayers, electricians, architects, engineers (civil and mechanical), designers, specifiers, building inspectors, approving authorities, manufacturers, suppliers, retailers, educators, painter/decorators, plasterers, roofers, glaziers, flooring installers, building managers and building owners. The circulation of BUILD at the time of the survey was approximately 12,000.

3.0 QUESTIONNAIRE DESIGN

This was an unsolicited survey without any personal direct contact between survey interviewer and respondent. The questionnaire (see Appendix 1) was formatted as a looseleaf two-sided A4 insert. The answers were put in multiple choice form to encourage as many replies as possible and to simplify the statistical analysis.

Space was allowed in the questionnaires for respondents to put in their own categories of types of plastics use. Similarly, at the end of the questionnaire, respondents were asked to state in their own words the problem most worthy of study in the use of plastics in buildings.

A period of approximately two months was allowed for respondents to return their forms.

The purpose of the survey was to examine the problems encountered with the various plastics used in New Zealand buildings. If it is assumed that the incidence rate of problems is the same for all types of plastics use then the number of problems would depend on the comparative amount of plastic used for each type of end product. This is providing things such as product size/weight, the likely aging mechanism, expected product lifetime and accessibility are ignored. Data for Australia in 1989 (Mitek, 1991) indicate that piping is by far the single largest application for plastics in buildings, accounting for about half of the market. Given that this usage of plastic piping is likely to be similar in New Zealand then it is expected, based on the above assumption, that piping would account for 50% of the problems in building plastics nationally. Using this as an initial premise for inclusion within the questionaire, the largest categories of plastic use were specifically surveyed except for the decision to exclude insulation plastics (i.e. rigid polyurethane, polystyrene, phenolic, and polyisocyanurate) and adhesives used in the manufacture of composite wood boards.

USA data (see Appendix 2) was used as the basis for inclusion within the questionnaire of the major types of plastic use. The survey thus specifically mentioned five main types of use: piping (including plumbing, drainage, spouting, conduit), vapour barriers, claddings, glazing materials (including rooflights, corrugated sheet and flat sheet) and floorings. In addition respondents were given the option of citing problems with any other types of plastics use.

The survey questionnaire was divided into two main halves. In the first half respondents were asked questions about all areas of plastics use in buildings including their amount of experience and the number of problems experienced. Respondents were then asked to select their major problem area and answer questions focusing on that problem area. Questions were asked about what caused the problems, the consequent cost for each type of problem, the mode of failure and the plastics material involved.

The choice of major plastics material types for the questionnaire were also taken from the same USA data (see Appendix 3). However urea, melamine, phenolic, polyurethane, polystyrene (all foams or adhesives), ABS (used a little in piping) and epoxy (used as floor topping or sealant) were not specifically mentioned. Polybutylene was included since it has a significant proportion of the NZ domestic water supply piping market.

Since no control was to be exercised over who returned questionnaires it was recognised from the outset that it would not be possible to conclude the total cost nationally of problems with plastics in building. This was because a higher proportion of people who did have problems compared to those who did not have any problems were expected to reply. However it did enable the identification and ranking of the major problem areas.

4.0 RESULTS AND DISCUSSION

4.1 General

The replies demonstrated a possible ambiguity in the questionnaire. Some respondents selected more than one ''worst problem area'' and then tried to answer questions 5 to 8 in the second half of the questionnaire accordingly (13% of respondents that chose a ''worst problem area'' did this). The answers for questions 5 to 8 from these respondents were not included in the analysis. Some respondents selected irrelevant failure modes, e.g., haze development in plastic piping (Figure 12) or plastics materials in areas with which they are not normally associated e.g. polycarbonate and acrylic in piping (Figure 11).

Some 298 responses were received with just 6 returns being excluded as a result of arriving after the analysis had begun. This represents a 2.5% response rate. If plastic users and specifiers only were surveyed this rate would have been higher. The (STD) telephone numbers supplied by respondents were analysed for regional area and compared with the population size (Department of Statistics, 1990) of the four main urban areas. Returns generally followed the population base (varying less than plus or minus 15%) in Christchurch, Dunedin and Auckland except for Wellington where almost 60% more returns were received than would be predicted (see Figure 1). This may be the result of BRANZ's location in Wellington plus also the larger number of regulatory bodies in the Capital. Only 16% of respondents were from the South Island versus a predicted 26% based on population. Note that this analysis does not take into account the possibility that the 'BUILD' magazine mailout may also have had a regional bias.

Respondents were given the opportunity to state their occupation at the beginning of the questionnaire. Over half of the replies were from either builders (27%) or plumbers/drainlayers (25%) followed then by approving authorities (14%) and architects (11%) (see Table 1 and Figure 2). All other individual occupation groupings each contributed less than 5% of responses. Closely related to this was Question One in the questionnaire proper which asked people to indicate their (organisation's) main function. Here subcontractors/installers represented 30% of the responding companies followed by builders at 28% and designers/specifiers at 17% (see Figure 3).

The practical experience of most respondents was very high. Almost 90% of respondents had at least 10 years experience in the building industry (see Figure 4). What was surprising was the number of people who had had more than 20 years experience - more than 50% - and greater than 30 years - more than 25% of respondents.

The results of the survey are largely a summation of the observations of users of plastic product rather than that of manufacturers, distributors (together making up only 4% of respondents) or others that may be seen to have a vested interest. In spite of this and despite the focus of the survey being on problems encountered with plastics, more than 85% of those who replied thought the performance of plastics in buildings was average or better (see Figure 5). Only 10% of people

expressed the view that performance was poor. As a group plumbers were more likely to be polarised in their opinion of plastics in building i.e. they either thought it performed well or it performed poorly rather than rating them as having average performance or expressing no opinion at all.

Of the five main types of plastics use, respondents were most familiar with plastic piping systems (see Figure 6). After piping, the product type that respondents had most experience with was plastic glazing followed by vapour barriers, claddings and floorings. This is contrary to the plastic tonnage statistics for the USA (Appendix 2) which has piping first followed in order by wall claddings, floorings, vapour barriers and glazings. This may be explained by the fact that PVC wall claddings have a much greater market penetration in the USA than in NZ. Further the USA tonnage for flooring includes flexible urethane foam used as carpet underlay.

Respondents were asked how many problems they had in each type of plastics use (see Figure 7). Respondents were next asked to state their "worst problem area" (see Figure 8). In most cases the area in which the most problems occurred was also their worst problem area. However other factors such as resultant cost and how easy it may be to solve those problems would have a bearing on the area chosen.

4.2 Types of Plastics Products With Most Problems

Plastic piping had easily the most problems with 59% of all respondents experiencing at least two or more problems (see Figure 7). More than 1 in 6 respondents said they had 16 or more problems with plastic piping over the last 5 years. Not all of these respondents were plumbers/drainlayers - 25% were from other occupations. Just over 50% of all responding plumbers/drainlayers said they had 16 or more problems with piping. Note however, that less than 18% of plumbers/ drainlayers indicated that the performance of plastics was poor.

Clearly second in the number of problems (approximately half that of piping) was plastic glazing. Claddings and vapour barriers had similar numbers of problems but only a quarter that of plastic glazing. Floorings had few problems with the incidence being about half that of claddings or vapour barriers.

4.3 The Most Frequently Cited Problems

4.3.1 Plastic piping

As expected plastic piping was chosen most frequently (52% of the time) as being the worst problem area (see Figure 8). Amongst those who chose piping as having the most problems, 29% of failures were considered to be due to faulty installation, 22% to faulty product design and 17% to manufacturing defects (see Figure 9). Problems resulting from poor installation were the most expensive to fix (see Figure 10). In individual cases consequential damage from piping failure may be high with one reported case of an insurance claim of $M1.2 (Stirling and Mitchell, 1988).

Problems with piping were examined more closely by considering the replies from plumbers/ drainlayers. This is the largest clearly defined grouping with detailed experience and knowledge of piping. In fact 94% of plumbers/drainlayers said that they had 10 or more years of experience. Perhaps not surprisingly, 88% of the plumbers/drainlayers who responded said that plastic piping

was their worst plastics problem area. Of interest is that plumbers/drainlayers singled out faulty installation more than any other single cause of piping failure. Faulty product design however, because it was more likely to result in multiple failures, caused the greatest total number of failures. Taken together, faulty product design and faulty manufacture were said by plumbers/ drainlayers to contribute more problems than all other causes combined. Builders, architects and approving authorities attributed more of the problems to faulty installation and somewhat less to manufacturing defect or faulty product design.

Polybutylene (29%), PVC (26%) and acetal (24%) plastics were the most commonly cited piping problem-causers (see Figure 11). Plumbers attributed fully a third of failures to acetal, followed by polybutylene (28%) and rigid PVC (22%). Far fewer problems were encountered in the use of polyethylene.

This result for polybutylene (PB) and acetal gives grounds for some concern, since PB usage is only about 2% by weight of PVC and acetal even less. On a per metre basis, however, this ratio will be reduced because PB is used in much smaller pipe diameter sizes and it is two thirds the density of PVC. From BRANZ's experience, the main source of failures in PB piping systems are the fittings. These may fail by cracking or breaking (acetal) or by becoming loose (acetal and occasionally metal fittings) and subsequently leaking (see also Figure 12). Not many of the problems are expected to relate to the piping itself although polybutylene has been known to split and occasionally to be gnawed through by rodents. There has also been some splitting of copper crimp rings and erosion or pitting of acetal fittings adjacent to brass nuts.

The results for piping encouraged BRANZ to subsequently conduct a survey (Trebilco, 1992) in the Nelson and Tasman regions to look at the number of plumbing failures there. The conclusion drawn was that for a domestic dwelling containing 30 acetal fittings and based on the current failure rate, there was a high probability that one of those fittings would fail in 10 years. This result is expected to be of largely historical significance however. It is known from the USA, that acetal fittings may be unreliable. Consequently the production of acetal crimp fittings has ceased except for one local manufacturer. The manufacturers have replaced acetal fittings with metal fittings which are expected to be more durable.

4.3.2 Plastic glazing

The second most significant problem area over all respondents was plastic glazing, being nominated by 26% of respondents as their worst problem area. Typically, poor weathering performance was given as the major reason for failure (see Figure 13). Weathering was also more costly than other causes of glazing failure (see Figure 14). This result is significant since the amount of plastic used in glazing (5% by weight for the questionnaire's major areas of plastics use in buildings) is much less than for piping (70%) - based on data for the USA (Modern Plastics, 1990). The major modes of failure were cracking and breaking followed by loss in transparency (see Figure 15). Materials with the highest percentage of total failures were PVC (34%), polycarbonate (18%), glass reinforced polyester (13%) and acrylic (9%) (see Figure 16). The proportions of these plastics may partly reflect their relative use - PVC will be used more because it is cheap. It is recognised that with the technology currently available this material will not make the most durable of plastic glazings when exposed in NZ conditions. There is a quality/price tradeoff between PVC and the other glazing plastics.

These results confirm the current emphasis in BRANZ research on investigating the durability of plastic glazing and, specifically, polycarbonate glazing materials. A programme of natural weather testing of polycarbonate materials has recently begun at BRANZ. An analysis was made of the replies from builders who chose glazing as their worst plastics problem area. The polymer with the largest number of problems was PVC - double that of the next named polymer, fibreglass reinforced plastic.

4.3.3 Vapour barriers

Perhaps because vapour barriers are less visible they were not considered to be much of a problem area excepting for approving authorities (e.g., Councils) who ranked it a clear second after piping. The major cause of problems with vapour barriers according to approving authorities was faulty installation. A BRANZ Bulletin describing the correct installation of vapour barriers used as damp proof membranes is now available (BRANZ, 1990).

Plastic reliability for each type of plastics use may be compared by considering only those respondents with a lot of experience in the respective areas versus the number of problems they are experiencing. About 78% of respondents with a lot of experience in vapour barriers had one or no problems over the last 5 years. On the contrary not many experienced respondents in piping (21%) or in glazing (17%) had only one or no problems during this period. This demonstrates the reliability of plastic vapour barriers generally.

4.3.4 Mouldings and extrusions

A type of plastics use not specifically mentioned in the survey questionnaire but chosen by 4% of respondents as their major problem area was mouldings and extrusions. Mouldings and extrusions include rigid PVC wall jointers and finishing strips as used in wet areas or for large sheet exterior claddings. This result is significant since it therefore ranks third, as a problem area, alongside vapour barriers. Possibly if it had been mentioned specifically in the survey questionnaire it would have ranked higher. Some 60% of failures occurred by cracking or breaking.

4.3.5 All types of plastic products

Taken over all types of plastics use, 31% of the total cost of failures was due to faulty installation followed by 18% caused by weathering. Some 60% of all failures were because of a plastic product cracking or breaking. Only 17% of products were deemed to have failed for aesthetic or appearance reasons.

5.0 CONCLUSIONS

The main problem area is plastic piping especially polybutylene systems followed by plastic glazing and possibly mouldings and extrusions.

Plastic piping is the subject of a subsequent survey (Trebilco, 1992). Polybutylene piping failures are expected to be largely historical since acetal fittings, often the main source of problems, are now being made in much lower quantities.

While the incidence of problems with rigid PVC glazing is high this must be balanced against its low cost compared to other plastic glazings. Manufacturers are now providing more reasonable assessments as to the likely durability of their PVC glazing products. Polycarbonate is the newest plastic glazing material and the second most often cited polymer with problems.

Little can be concluded about plastic mouldings and extrusions since 4% of respondents, although significant, still represents just 11 people. Failure mainly occurred by cracking and breaking. Installers should be aware that the impact strength of rigid PVC is not great especially at low temperatures and that care needs to be exercised when installing plastic extrusions such as jointers.

6.0 FUTURE WORK

The results of the subsequent plumbing survey are currently being prepared in a separate report. Any recommendations for future work on polybutylene plumbing systems will be included in that report.

The reasons for PVC glazing failure are quite well understood and it requires education of installers and users to prevent premature failure rather than research. Polycarbonate is the newest of the glazing plastics and the technology is still evolving. A research programmme on approximately twenty currently available polycarbonate glazing materials has recently begun. This project is examining the effects of the various protective coating systems, polymer colour and cold bending on the durability of polycarbonate.

Problems with mouldings and extrusions are expected to be mainly related to PVC's impact strength. This requires education of installers rather than research.

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Figure 1. Distribution of Survey Responses for N.Z.s Main Urban Areas

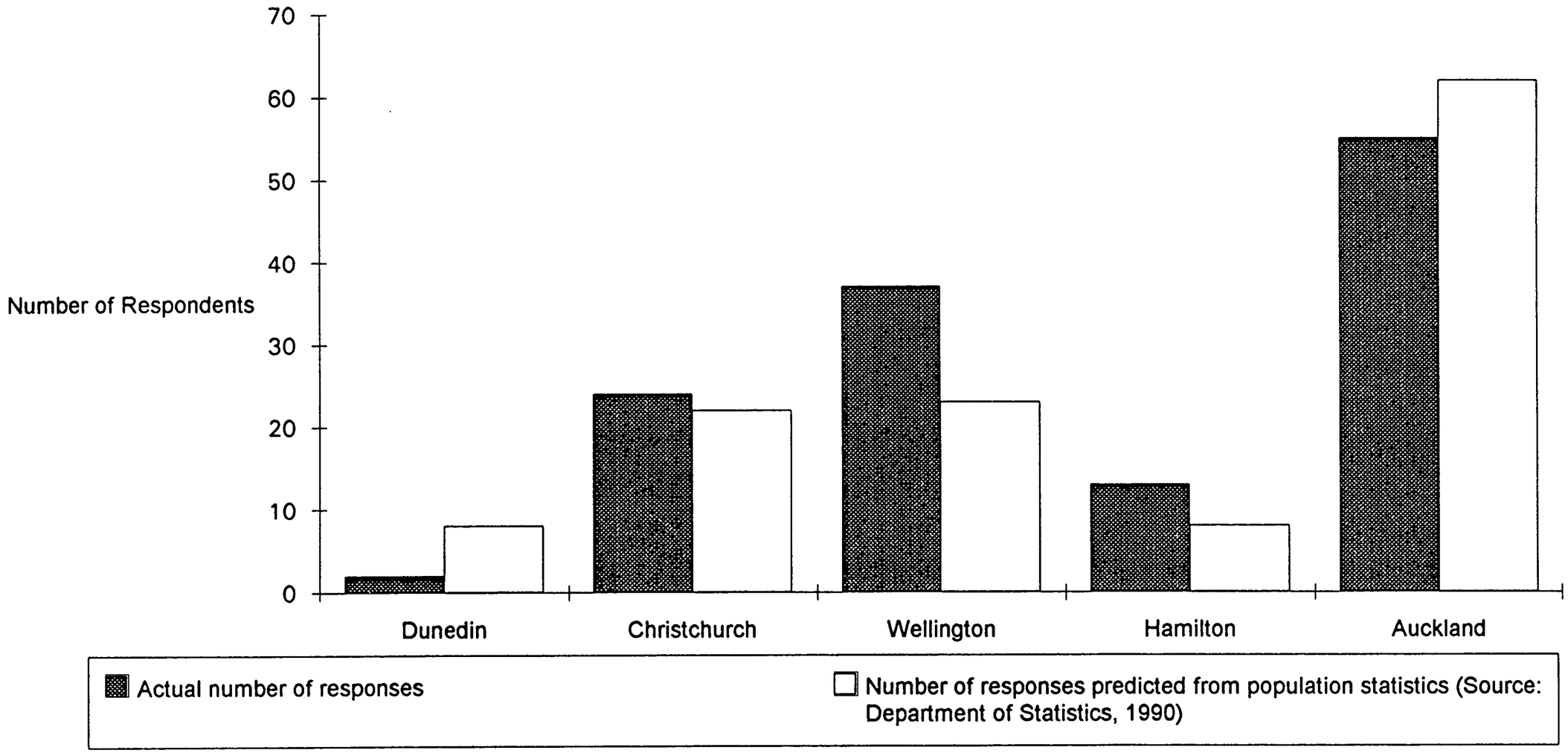


Figure 2. Responses To Survey From Each Occupation Grouping

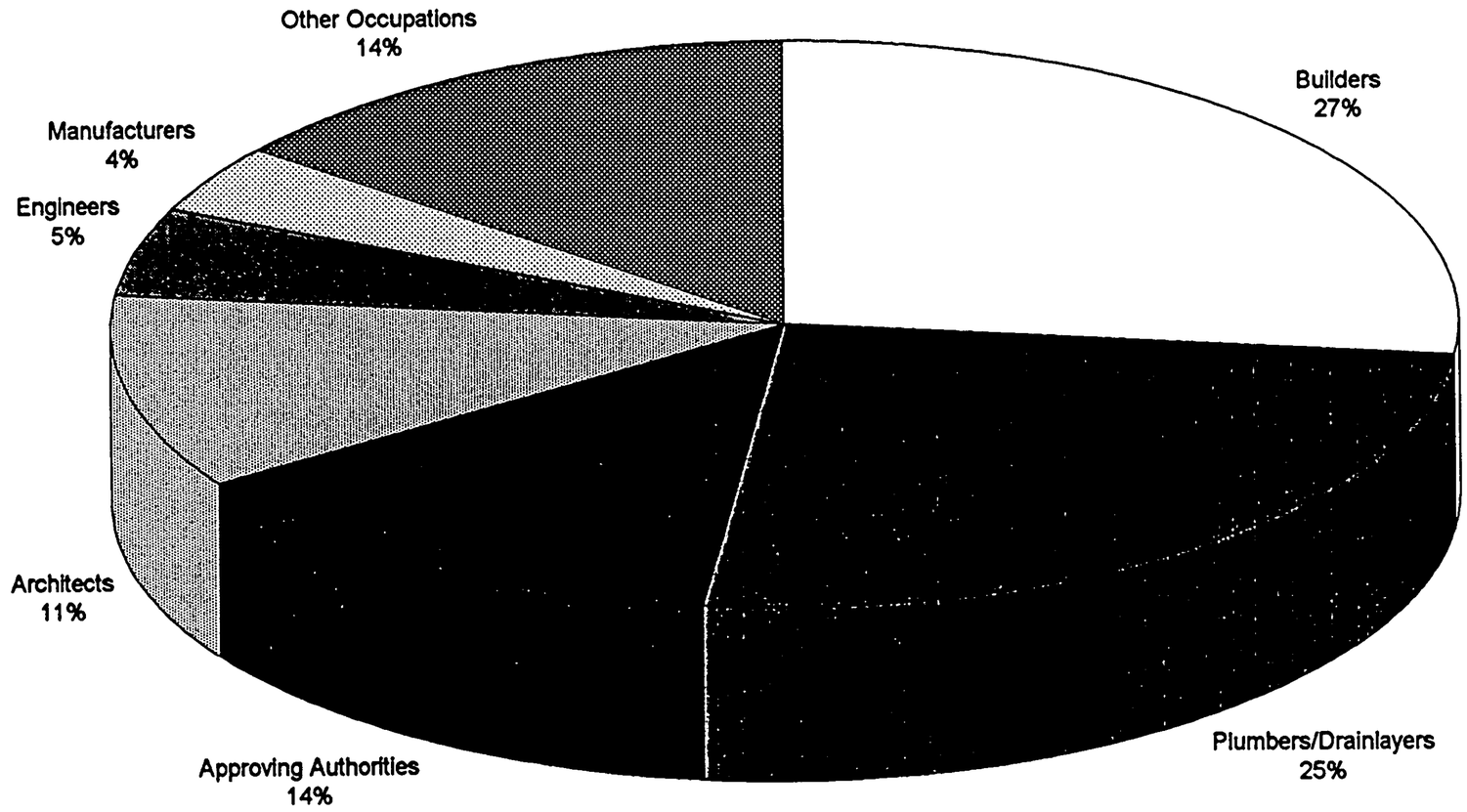


Figure 3. Main Company Function vs Percent of Respondents

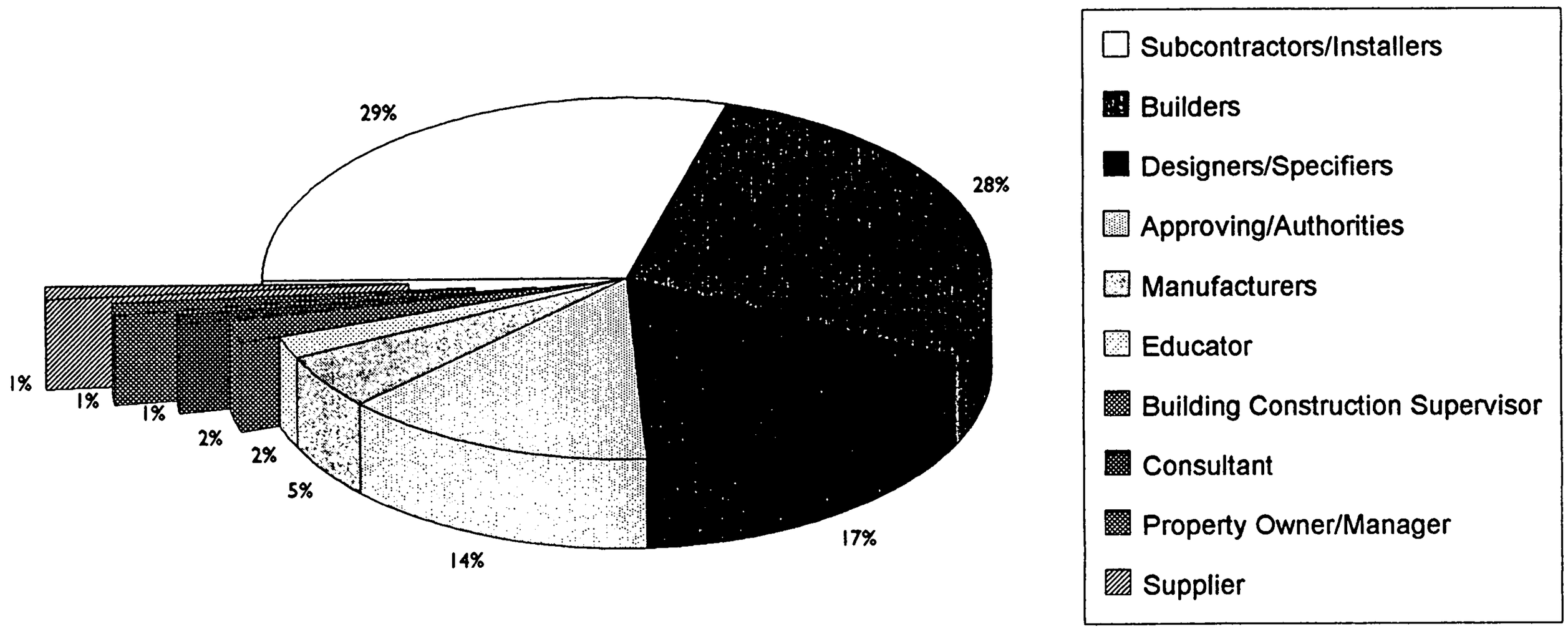


Figure 4. Years of Occupational Experience vs Percent of Respondents

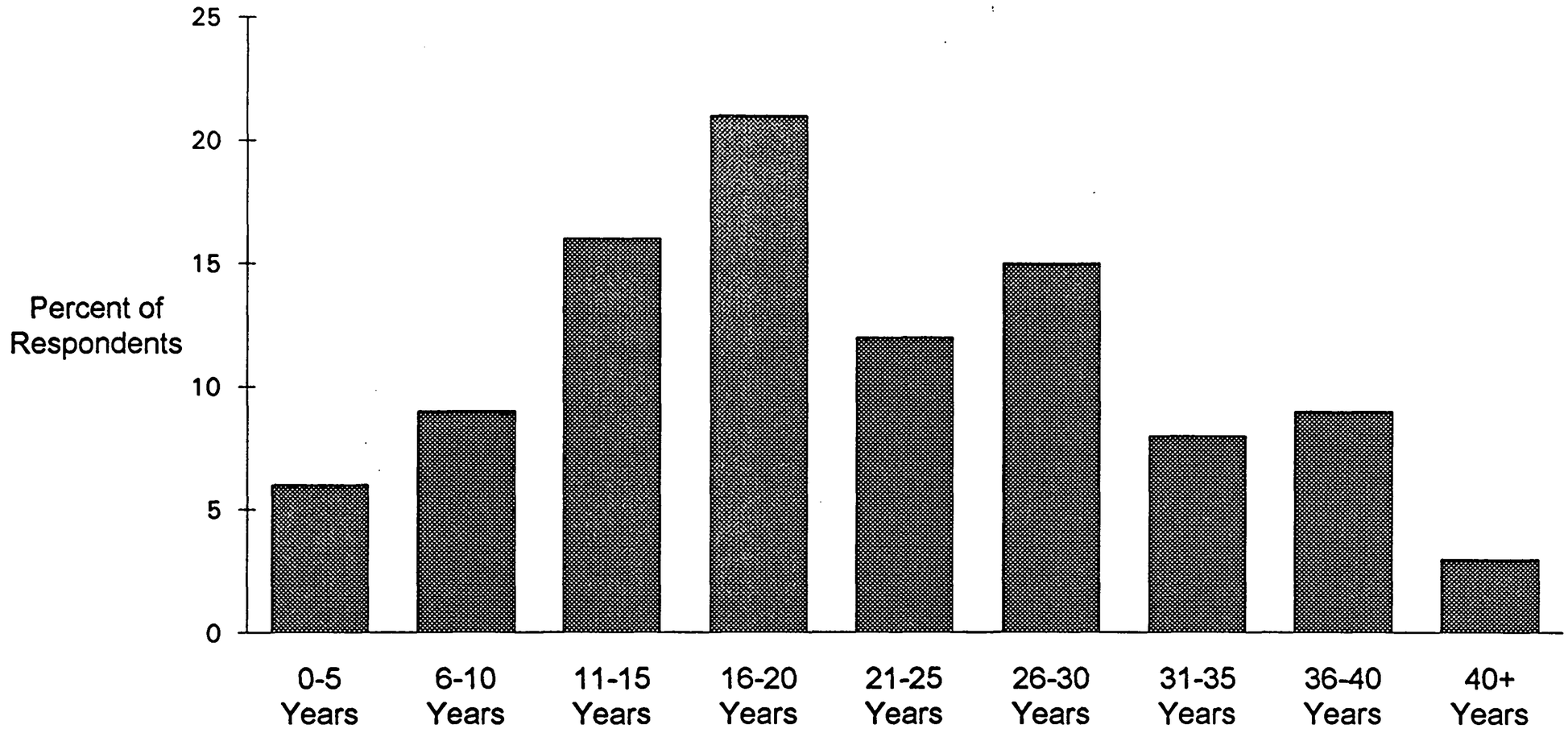


Figure 5. Opinion of Plastics Performance

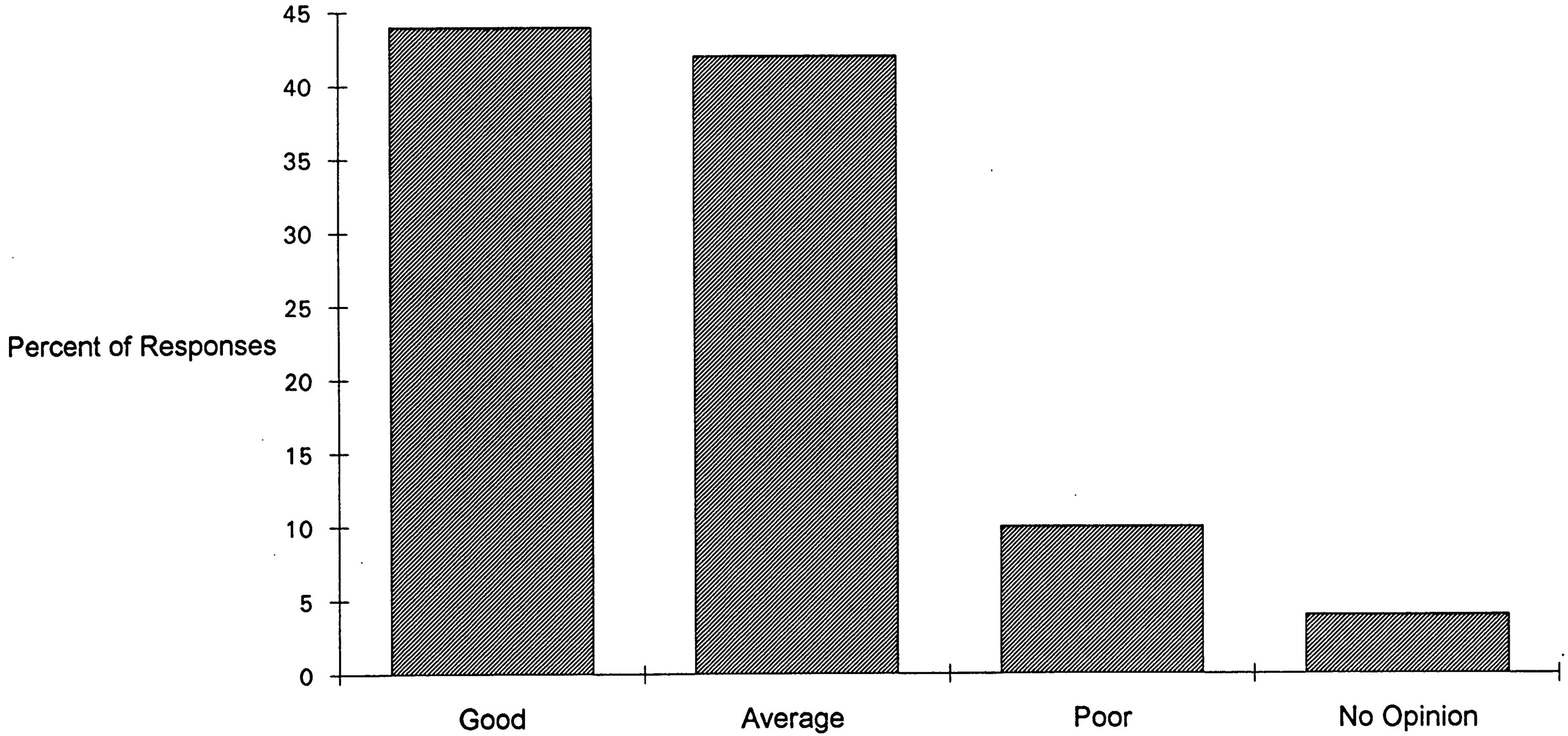


Figure 6. Experience in Plastics

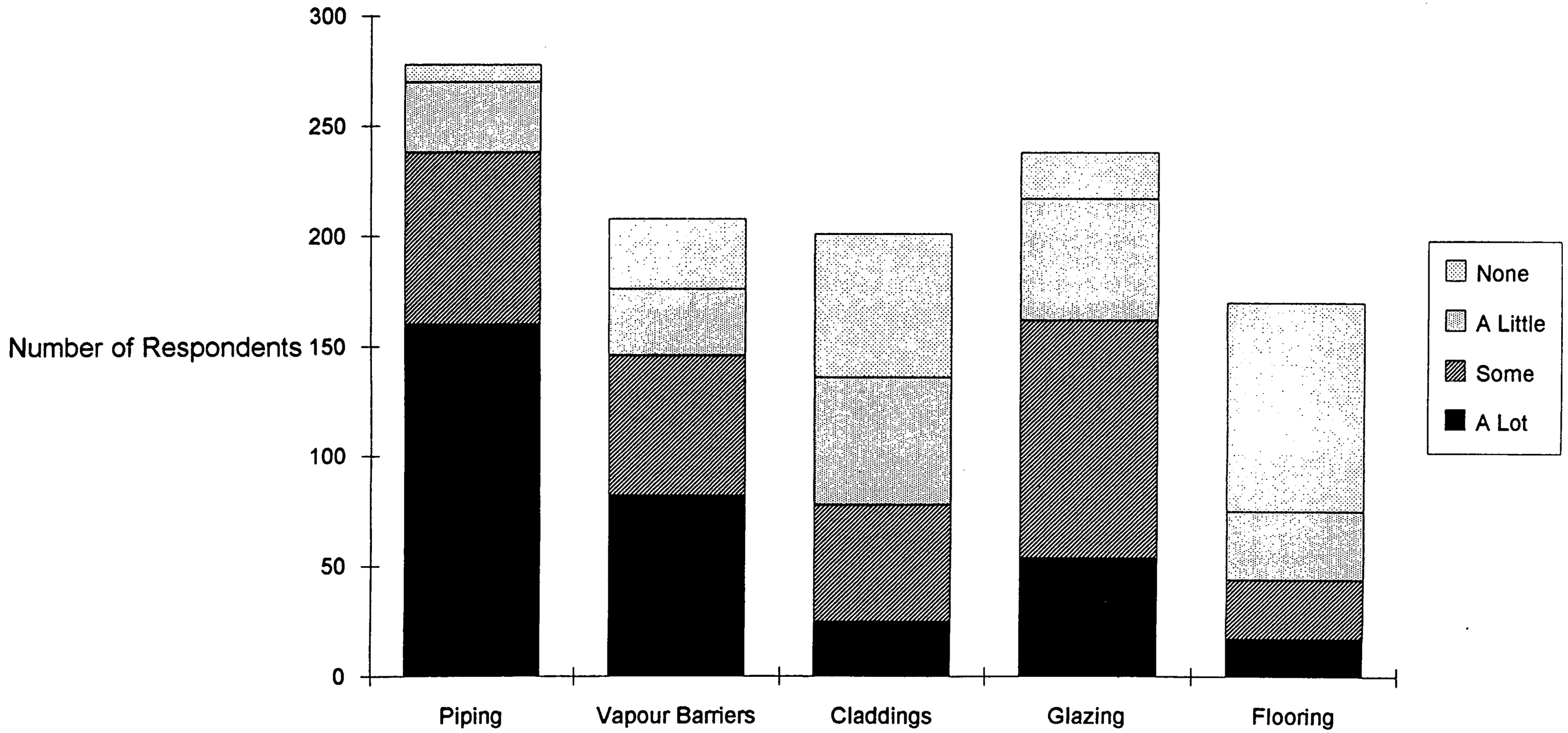


Figure 7. Number of Problems For Each Type of Plastics Use

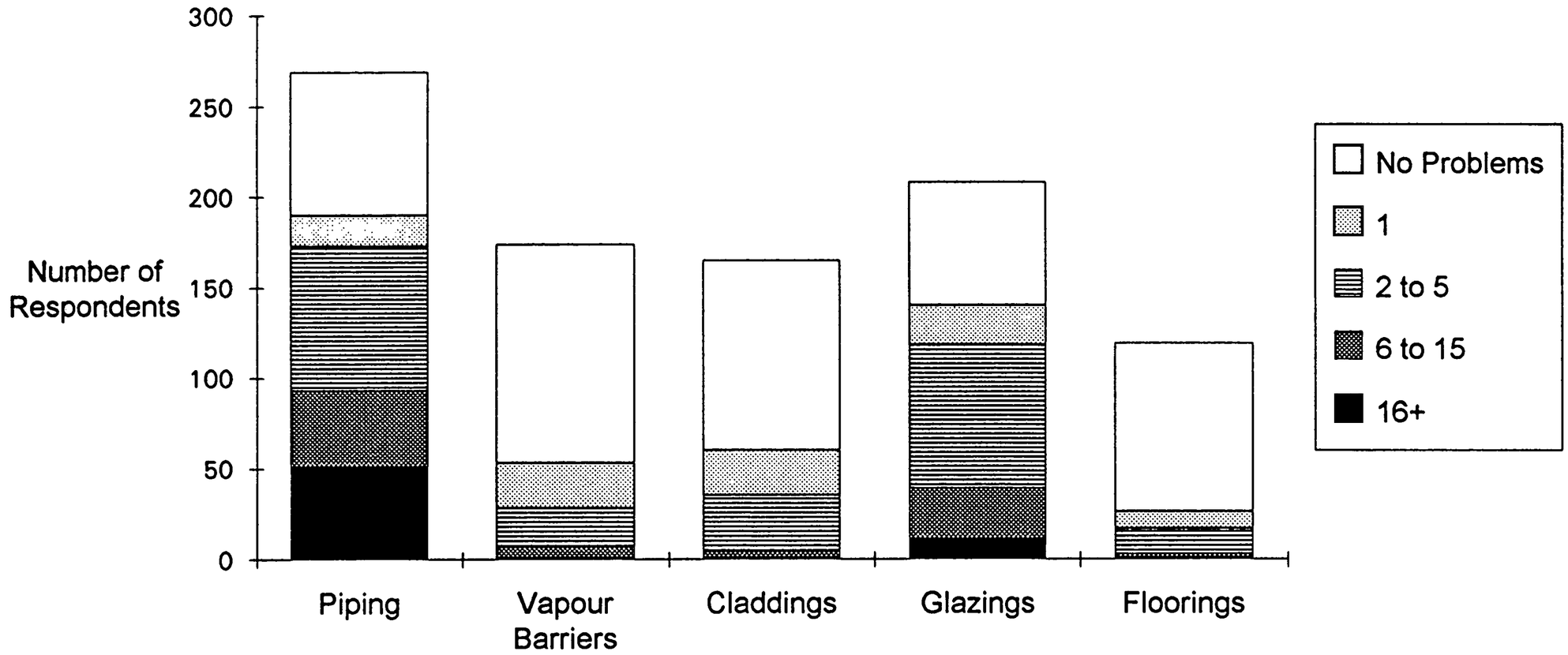
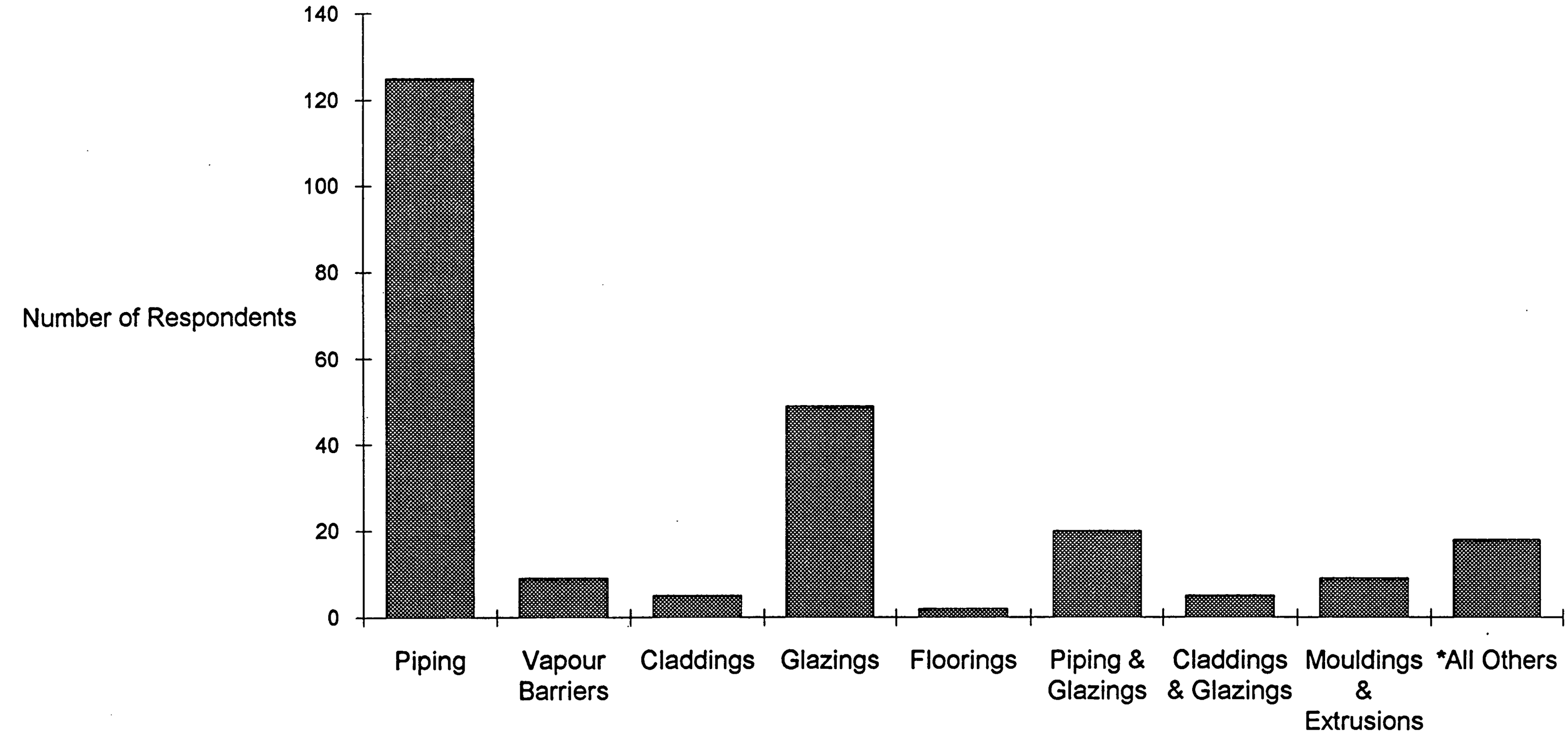


Figure 8. Choices of Major Problem Areas



* Includes sanitary fittings, coatings, electrical fittings and cable, mouldings and glazings, benchtops, sealants, miscellaneous plastic fittings, piping and claddings, piping and sanitary fittings.

Figure 9. Number of Piping Problems for Each Cause

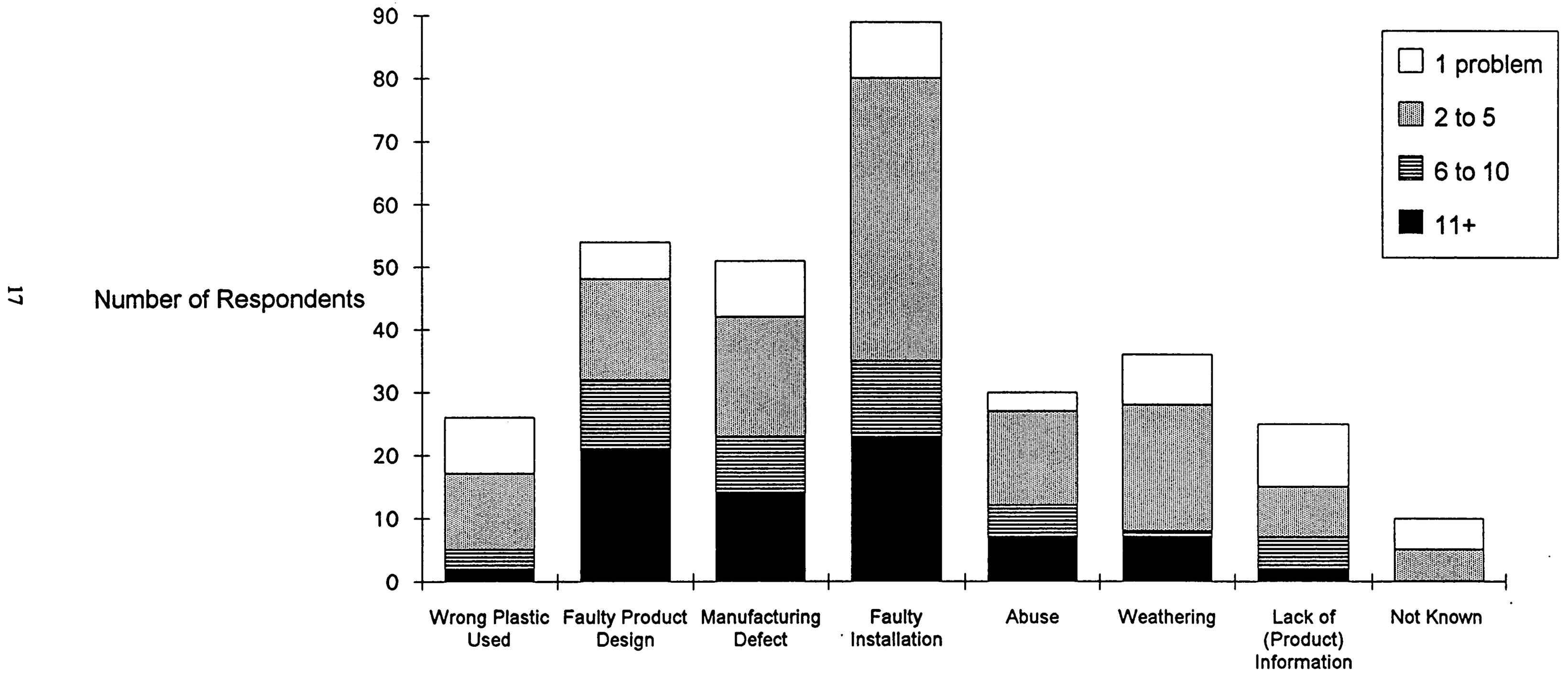


Figure 10. Cost of Each Cause of Piping Problems

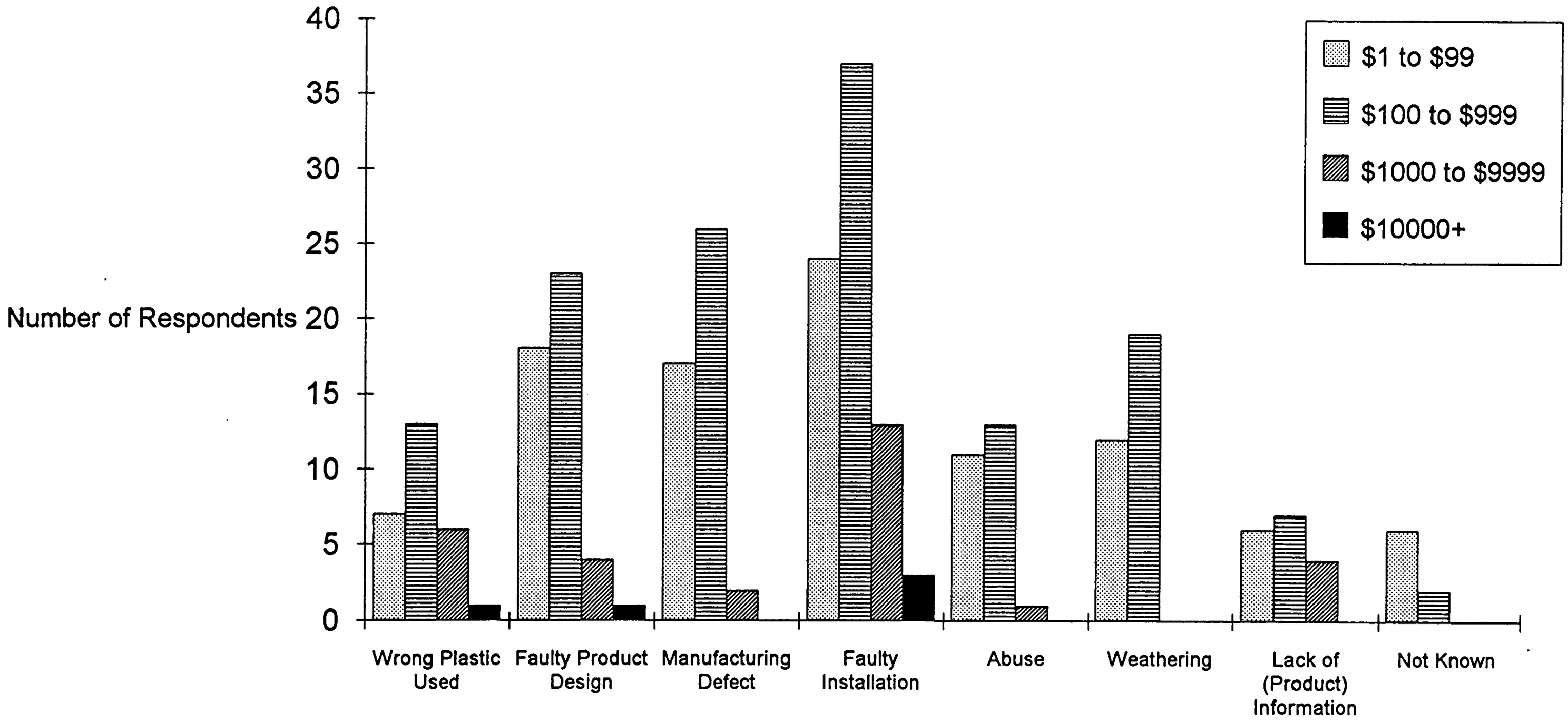


Figure 11. Number of Piping Problems in Each Plastic Material

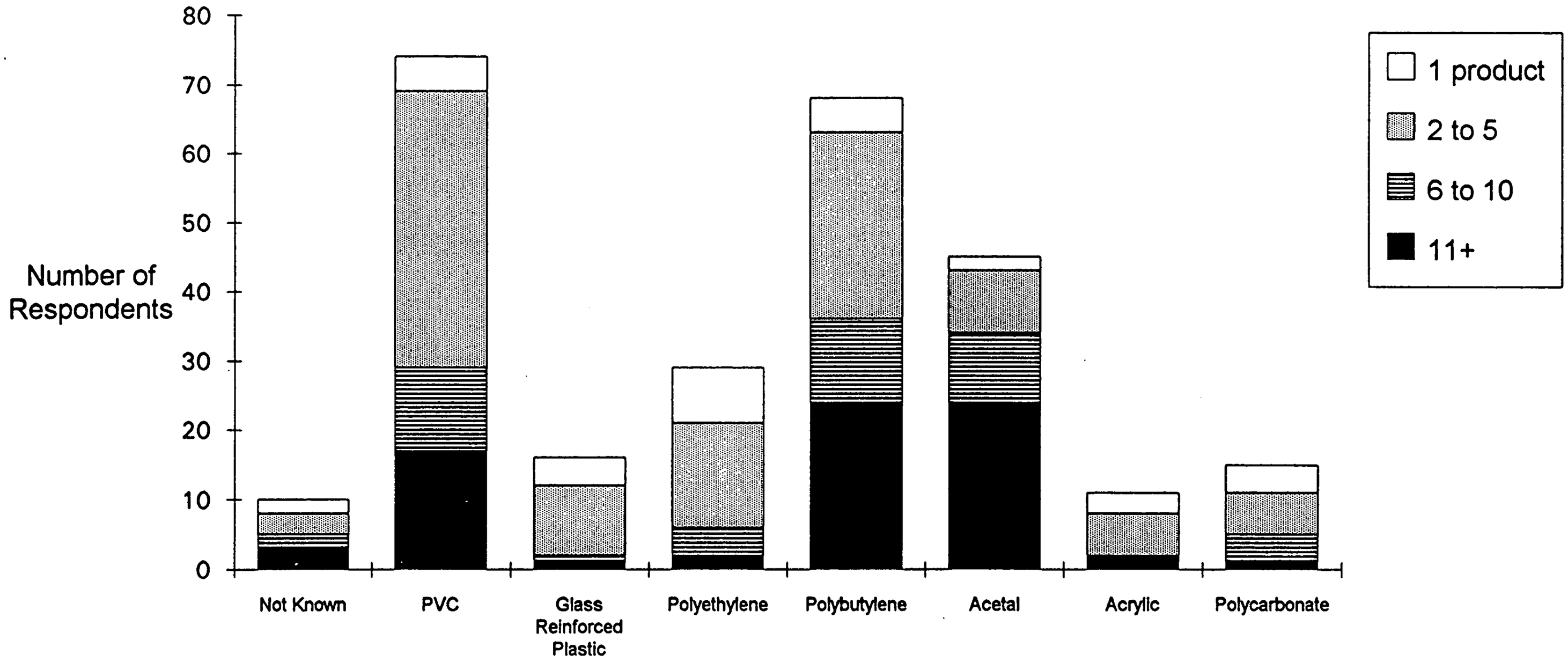


Figure 12. Numbers in Each Piping Failure Mode

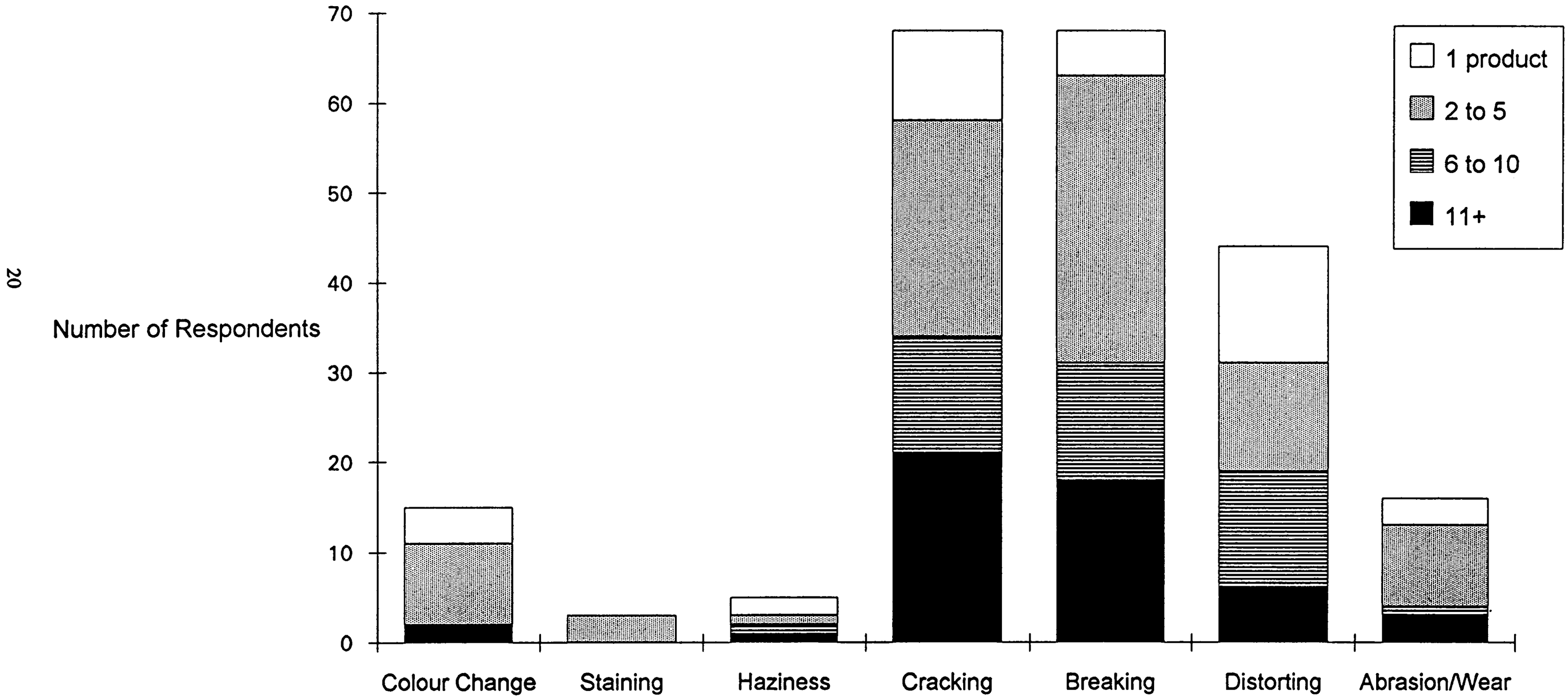


Figure 13. Number of Glazing Problems for Each Cause

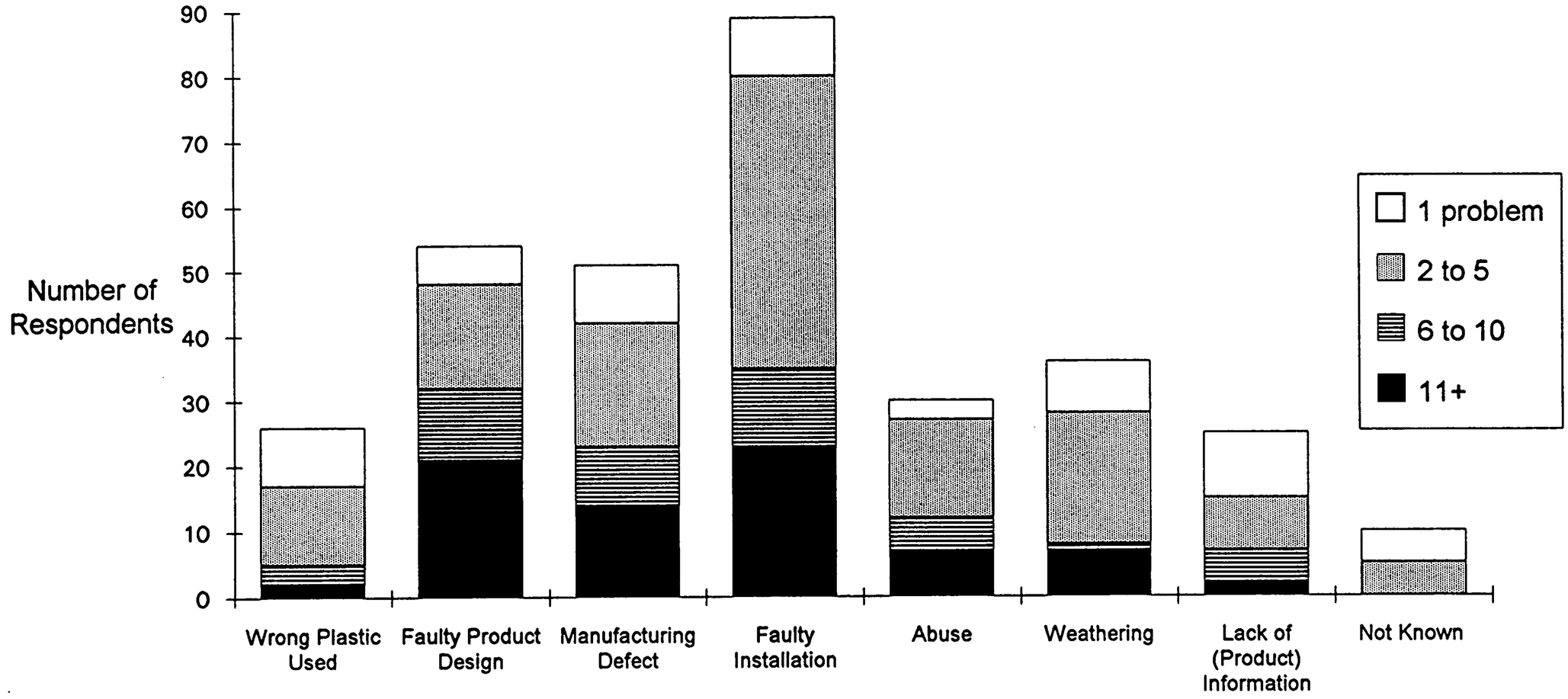


Figure 14. Cost of Each Cause of Glazing Problems

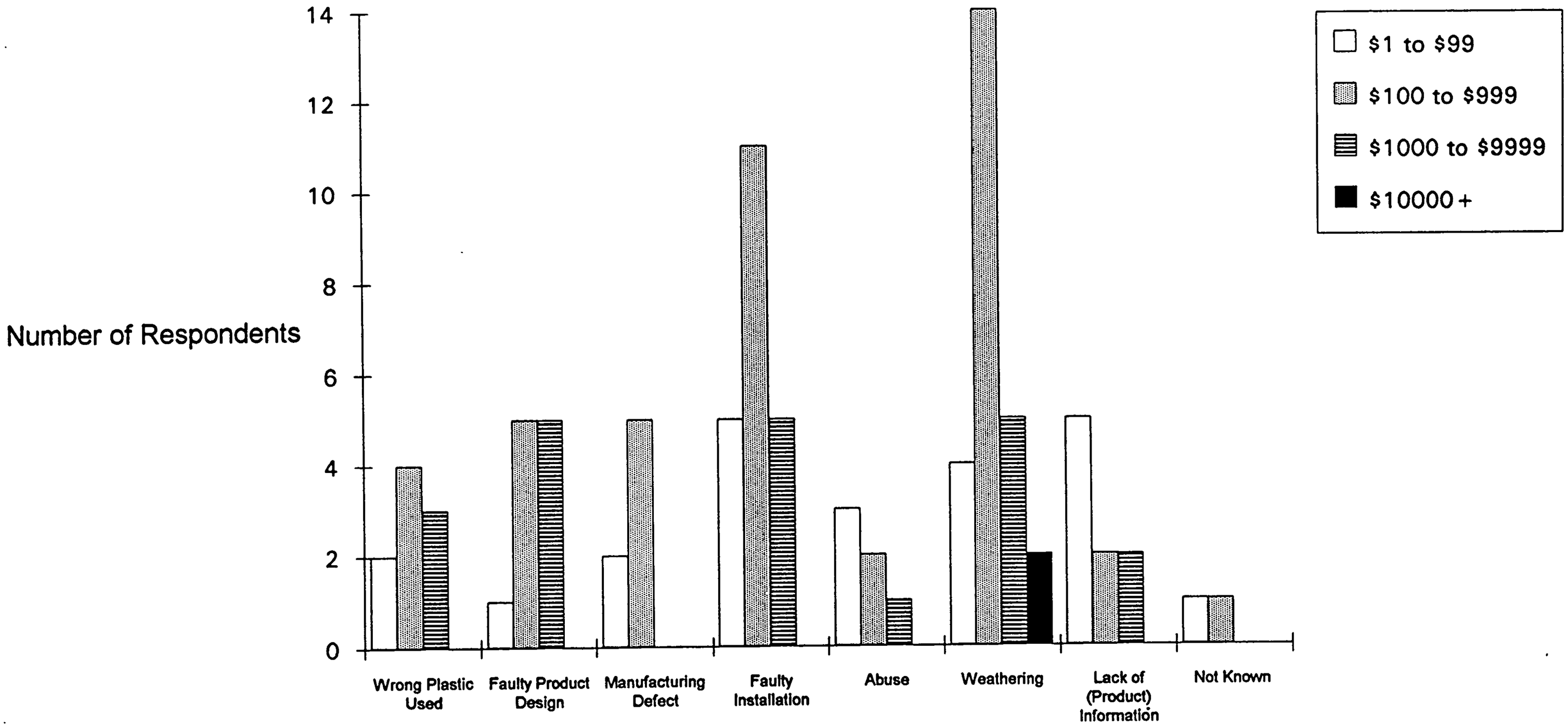


Figure 15. Numbers in Each Glazing Failure Mode

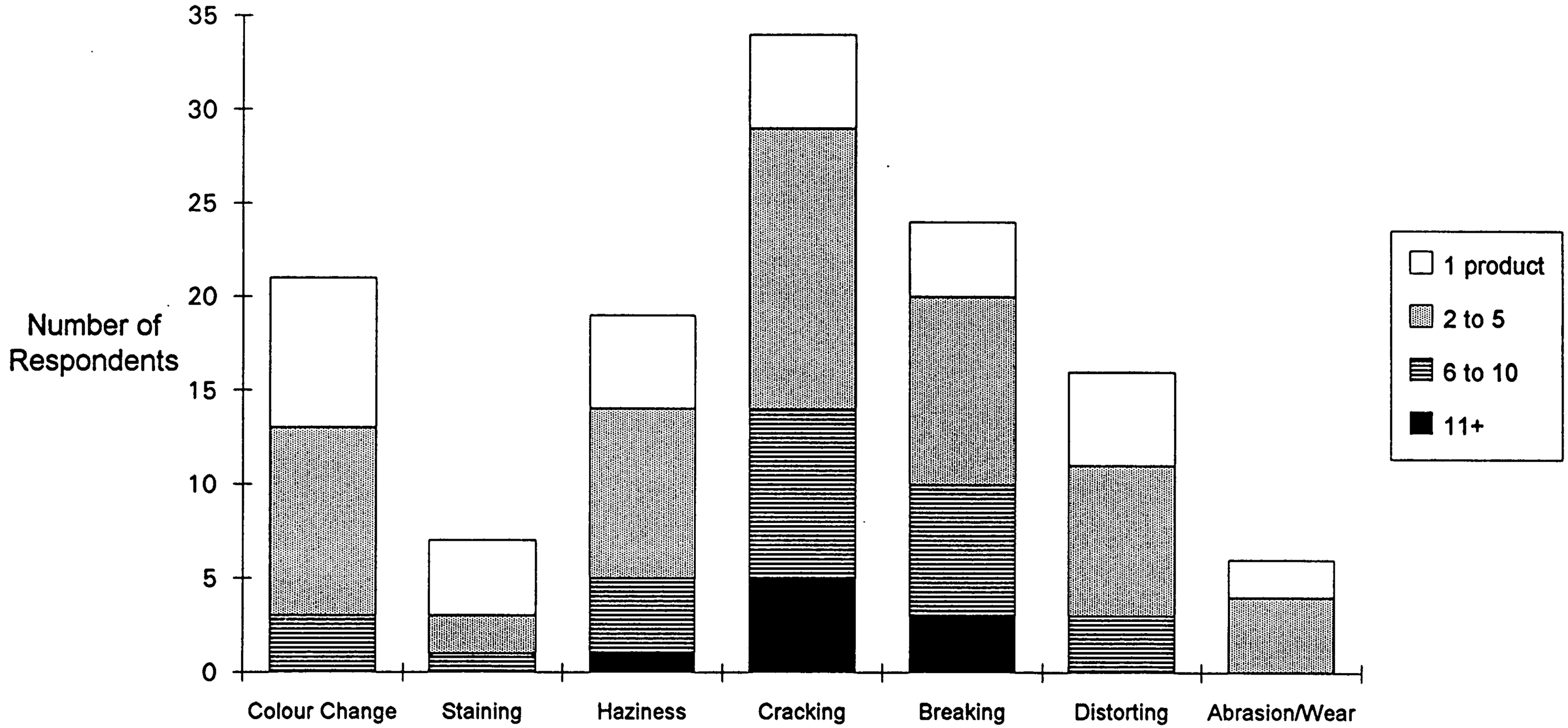


Figure 16. Number of Glazing Problems in Each Plastic Material

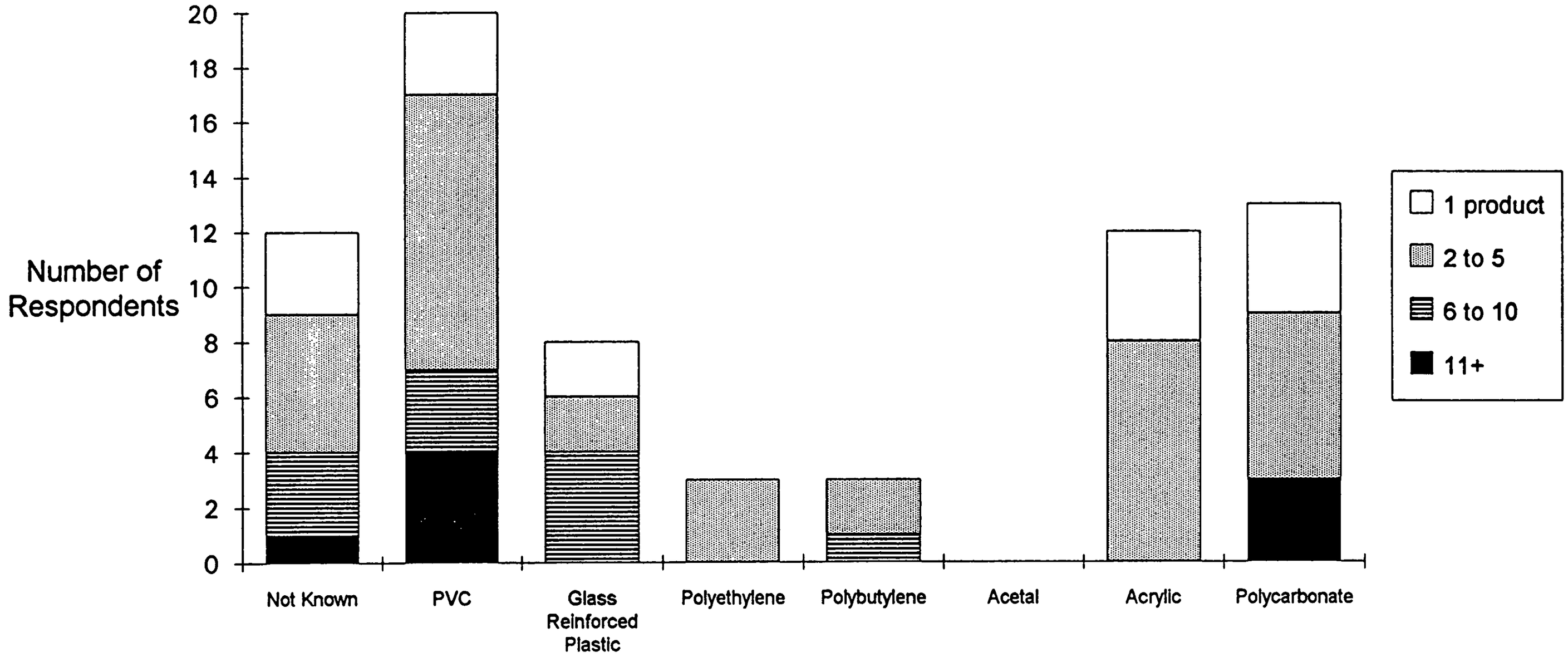


Table 1. Occupation vs Percent of Respondents

Builders	27%
Plumbers/Drainlayers	25%
Approving Authorities	14%
Architects	11%
Engineers	5%
Manufacturers	4%
Electrical Contractor	2%
Building Construction Supervisor	2%
Window Manufacturer	1%
Educator	1%
Draughtsman	1%
Building Consultant	1%
Building Manager	1%
Project Manager	1%
Roofer	1%
Director of Building Company	1%
Painter/Decorator	<1%
Masonry Contractor	<1%
Retail Manager	<1%
Cladding Installer	<1%
Glazier	<1%

Appendix 1: Questionnaire Survey of Building Plastics

SURVEY OF BUILDING PLASTICS

This questionnaire is part of a survey to discover the type and incidence of poor performance of plastic materials used in buildings. Your help will enable BRANZ to better assess the areas of plastics use that require technical investigation.

Please pass this questionnaire or photocopies of it, to the person(s) in your organisation who is most experienced with plastics used in buildings.

Name (optional): _____ Phone (inc/STD) No. _____

Occupation: _____ Years experience: _____

1. Tick which best describes your (organisation's) function

Designer/Specifier	☐	Manufacturer	☐
Approving Authority	☐	Supplier	☐
Subcontractor/Installer	☐	Builder	☐
Property Owner/Manager	☐	Other _____	☐

2. Do you think the performance of plastics (in buildings use) is generally

Good ☐ Average ☐ Poor ☐ No Opinion ☐

3. In each of the following areas how much experience have you had with plastics use in buildings?

	A lot	Some	A Little	None
Piping (including plumbing, drainage, spouting, conduit)	☐	☐	☐	☐
Vapour barriers	☐	☐	☐	☐
Claddings (including fibreglass, plastic weatherboards)	☐	☐	☐	☐
Glazings (including roof lights, corrugated sheet)	☐	☐	☐	☐
Floorings	☐	☐	☐	☐
Other _____	☐	☐	☐	☐
Other _____	☐	☐	☐	☐

4. Indicate the number of problems experienced in the last five years by ticking the appropriate box.

	None	1	2 - 5	6 - 15	16+
Piping	☐	☐	☐	☐	☐
Vapour barriers	☐	☐	☐	☐	☐
Claddings (including fibreglass, plastic weatherboards)	☐	☐	☐	☐	☐
Glazings (including roof lights, corrugated sheets)	☐	☐	☐	☐	☐
Floorings	☐	☐	☐	☐	☐
Other _____	☐	☐	☐	☐	☐
Other _____	☐	☐	☐	☐	☐

If you answered <u>none</u> for <u>all</u> areas in question 4 then please return the questionnaire to the address overleaf. Otherwise continue on.

For questions 5 to 8, select your worst problem area from question 4.

Write it here _____

5. How many of the problems were due to

	1	2 - 5	6 - 10	11+
Wrong plastic used	☐	☐	☐	☐
Faulty product design	☐	☐	☐	☐
Manufacturing defect	☐	☐	☐	☐
Faulty installation	☐	☐	☐	☐
Abuse	☐	☐	☐	☐
Weathering	☐	☐	☐	☐
Lack of (product) information	☐	☐	☐	☐
Not known	☐	☐	☐	☐
Other _____	☐	☐	☐	☐

6. For each of the causes what was the average cost of failure (in $)?

	1-99	100-999	1000-9999	10000+
Wrong plastic used	☐	☐	☐	☐
Faulty product design	☐	☐	☐	☐
Manufacturing defect	☐	☐	☐	☐
Faulty installation	☐	☐	☐	☐
Abuse	☐	☐	☐	☐
Weathering	☐	☐	☐	☐
Lack of (product) information	☐	☐	☐	☐
Not known	☐	☐	☐	☐
Other _____	☐	☐	☐	☐

7. How many of the products were deemed to have failed because of

	1	2 - 5	6 -10	11+
Colour change	☐	☐	☐	☐
Staining	☐	☐	☐	☐
Haziness	☐	☐	☐	☐
Cracking	☐	☐	☐	☐
Breaking	☐	☐	☐	☐
Distorting	☐	☐	☐	☐
Abrasion / Wear	☐	☐	☐	☐
Other _____	☐	☐	☐	☐

8. How many problems were there in each plastic type?

	1	2 - 5	6 - 10	11+
Not known	☐	☐	☐	☐
PVC	☐	☐	☐	☐
Fibreglass (reinforced plastic)	☐	☐	☐	☐
Polythene	☐	☐	☐	☐
Polybutylene	☐	☐	☐	☐
Acetal	☐	☐	☐	☐
Acrylic	☐	☐	☐	☐
Polycarbonate	☐	☐	☐	☐
Other _____	☐	☐	☐	☐
Other _____	☐	☐	☐	☐

9. Please describe what you consider to be the problem most worthy of study in the use of plastics in buildings. (Attach additional page if necessary).

_____

_____

_____

Thanks for your help.

Please return completed questionnaire to:

Freepost No. 3240
BRANZ
Private Bag
PORIRUA

By 30 September 1990

Any queries please contact Neil Trebilco or Wayne Sharman. Ph. (04) 357-600 Fax (04) 356-070

Appendix 2. Comparative Use of Construction Materials Made of Plastic

Product	% of Total Plastics Used	
	1979	1990
Exterior pipe, interior and exterior conduit	58	52
Insulation	12	12
Flooring	8	9
Siding and exterior panels	6	12
Vapour barriers	3	3
Plumbing fixtures	3	2
Glazing	3	3
Extruded profiles	3	4
Wall covering	2	1
Decorative laminates	1	1
Lighting fixtures	1	1
	100	100

Figures are for the USA
* Excludes resin bonded wood/timber

Appendix 3. Plastics Used in Construction Materials

Types of Plastic Material *	% of Market 1979	1990
PVC	43	45
Urea and melamine	12	9
Phenolic	10	19
Fibre-reinforced polyester	7	4
HDPE	7	5
Polyurethane foam	5	7
ABS	5	1
Polystyrene foam	3	2
LDPE	3	3
Acrylic	2	2
Polycarbonate	1	1
Polystyrene	<1	1
Other (incl epoxy, polypropylene, acetal et al)	2	1
	100	100

Figures are for the USA
* Includes resins used in bonded wood/timber

Note: There has been a 40% increase in the amount of plastics used in construction in the USA in the period 1979 to 1990.

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