REMEDIES FOR DEFECT ACCIDENTS

Contribution to XXI FISITA Congress, Belgrade, Yugoslavia, 2-6 June 1986

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ABSTRACT

A not inconsiderable share of accidents is partly caused or worsened by vehicle faults. These faults - the collapse of parts - occur when it is not recognized in time that parts are not functioning as they should do. The shorter the time between complete functioning and complete failure of parts "the deterioration span" the greater the chance that the defect will not be recognized in time, especially important and heavily loaded parts of a vehicle, such as brakes and tyres, have short deterioration spans. Therefore they form the greatest part of defect accidents. Faults can among others be remedied by design measures, such as safety margins and double or separate systems; or in the phase of use, like preventive maintenance, periodical inspection and fault-indication in or at the vehicle. It will be shown that it is important to look at maintenance habits of motorists and that fault indication can offer a good solution in prevention defect accidents.

INTRODUCTION

A considerable proportion of accidents are partly caused, or aggravated, by mechanical faults. This paper considers the incidence of accidents involving mechanical faults, the nature of the faults, the connection with vehicle age and the various precautions that can be taken. The restricted effect of periodic motor vehicle inspection and the value of fault indicators on the instrument panel will also be discussed. We shall be considering not only the technical aspects but also the maintenance behaviour of vehicle owners.

ACCIDENTS

Accidents are caused by a combination of circumstances. In very few cases is there something which is THE cause of an accident; normally we can only talk about something being "one of the causes". When taking steps to deal with a particular cause we must remember that removing one of the causes is not going to eliminate all the accidents in which that cause is a contributory factor. Furthermore, isolated measures can sometimes make the situation worse in some other area. Only a combination of interrelated and complementary measures has any chance of success, and this also applies to measures designed to prevent accidents involving mechanical faults.

PROPORTION

Data on the extent to which mechanical faults influence the occurrence of accidents are obtained mainly from police statistics or from specially designed accident surveys. Sometimes insurance data can be used. When dealing with an accident the police are likely to be concerned to a large extent with the legal aspects, e.g. infringements of the law and the question of liability, depending on the seriousness of the accident. If there is apparently a clear case of human error, the technical condition of the vehicle is not likely to be examined. In many cases the skills required for this are not available anyway. Easily detected shortcomings, e.g. worn tyres and inadequate lighting, may well be overrepresented. The proportion of accidents involving mechanical faults according to police records is therefore likely to be on the low side.

In accident surveys an accident is studied in detail, including a visit to the scene of the accident and an inspection of the vehicle; the motorist is questioned if this is possible. The resulting data are usually based on limited numbers of accidents. Factors which can influence the study include inaccurate statement of the facts by the motorist, an insufficient number of accidents studied and bias on the part of the research worker: engineers are inclined to find more mechanical faults than human errors, whereas psychologists may have precisely the opposite tendency.

Interpreting the causes of an accident is a difficult matter: often it is no longer possible to ascertain whether a fault already existed before the accident or was a result of it. If the sample in an accident survey is not compared with a control group of vehicles not involved in accidents there is a risk that the estimated number of accidents involving mechanical faults will be too high: faults which have little or nothing to do with the accident can be interpreted as causal or contributory factors. A reasonable approach, therefore, would be to regard the percentages of accidents involving mechanical faults found in accident surveys as maximum figures.

The proportion of accidents caused by mechanical faults given in the literature ranges from about 2 percent in police statistics to about 4 to 6 percent in accident surveys. The proportion where faults are a contributory factor varies from about 8 to 21 percent (Treat & Joscelyn, 1973; Treat e.a., 1977; SWOV, 1974; Tromp, 1985). Braking system faults account for about 40 to 60 percent of these, and defective tyres for about a quarter; faults in other components are of only modest significance (Treat & Joscelyn, 1973; Treat e.a., 1977; DEKRA, 1983) (Figure 1).

RISK

A new vehicle covers more kilometers per year than an older one, but it is also less susceptible to mechanical faults. If we look at all vehicles registered in a particular year, the number remaining decreases each year (as does the number of accidents in which they are involved) whereas the percentage involved in accidents rises. American research (Treat e.a.,

1977) suggests that accidents involving mechanical faults are about 1.6 times more frequent in the case of 4 to 6-year-old vehicles, and about 3.5 times in the case of vehicles at least 7 years old, than in that of vehicles less than 4 years old. It is known, however, (OECD, 1975; Tromp, 1985) that old vehicles are driven by a higher percentage of young people, who because of their lack of experience (and greater inclination to take risks) are more often involved in accidents. The increased risk due purely to the vehicles is therefore probably lower than these figures would suggest.

MECHANICAL FAULTS

A component may develop a mechanical fault owing to wear and tear, age or momentary or lasting overload. There may be a relationship between faults and such things as state of repair and vehicle age, driving habits, road maintenance and use.
Two kinds of fault can be identified:
- sudden failures, and
- faults which develop gradually.

Sudden failures can be regarded as an immediate threat to road safety, and they can also be the cause of a good deal of inconvenience, e.g. delays and high repair costs. Developing faults can even result in sudden failures if they are not recognised in time, owing to lack of inspection.

DETERIORATION SPAN

The term "deterioration span" is applied to wear and tear of components: this is the period during which a component deteriorates from a fully operational state to complete failure. The likelihood of detecting a fault is related to the components deterioration span and the detectability of the particular fault. If the deterioration span is shorter than the interval between inspections, and the fault is moreover one which is difficult to detect, there is very little chance of detecting it before the component fails completely. The chance of detecting a fault in time is much greater if the deterioration span is much longer and the fault is one which is easy to detect. It is therefore not surprising that, as the research data mentioned above show, components with a short deterioration span, e.g. brakes and tyres, are most frequently represented in accidents involving mechanical faults. Brakes, for instance, are susceptible to leakages of brake fluid and tyres to low pressure: in such cases the deterioration span can be very short - the length of a journey, for example.

PRECAUTIONS

The components which need to be considered first as regards preventing accidents are those which are trouble-prone and have a short deterioration span. Various types of precaution can be taken. Systems can be simplified at the design stage: the fewer the parts, as a general rule, the lower the risk of faults. Replacement, however, may be more expensive. Designs can include emergency back-up features or safety margins, or systems can be divided or duplicated, as is already the case with braking systems. Simplified servicing, with lower maintenance costs, makes vehicles cheaper to run, and essential maintenance is less likely to be postponed as a result.

The type approval requirements for new vehicles could be made more stringent on the basis of such things as accidents and maintenance data. Police inspections and periodic motor vehicle inspection can be employed for vehicles already in use. Other possibilities include improving the quality of the road network and educating motorists on the need to inspect their vehicles regularly themselves. Fault indicators in or on the vehicle are another way of giving a warning. All these methods are already in use to a varying extent.

EFFECTS

Improved designs may postpone component failure, but they cannot prevent it alltogether. Because it takes longer for a fault to occur, however, there is a reduction in the number of faults. Sudden failures cannot be prevented by maintenance unless this is of a preventive nature: this entails replacing components after a certain length of service even they are not defective or visibly worn. This is not very worthwile in the case of cars. Owners of new vehicles generally trade them in after a few years; from their point of view preventive maintenance would increase the cost without providing any noticeable benefits. Subsequent owners are out to keep the immediate cost as low as possible, and are therefore inclined to carry out symptom-related maintenance, i.e. replace parts as they become faulty.

The cost of vehicle maintenance has been reduced in recent years by increasing the service interval. However, this also means that they are less frequently examined for faults, and components with a short deterioration span run a greater risk of developing faults between inspections. Average mileage in the Netherlands is about 12.500 km a year. The average for older vehicles is lower. The recommended mileage between inspections is gradually increasing, and in some cases now exceeds this average. The service intervals for many vehicles are now expressed in terms of time rather than mileage; servicing is usually required once a year in this case. The risk of faults is greater in older vehicles (Abbene, 1978) (Figure 2), and annual inspection is therefore not enough. It makes sense to base inspection and servicing periods on vehicle age and, additionally, on owners maintenance habits. Incidentally, unnecessary obstacles are often placed in the way of obtaining information and parts, despite the fact that this is a lucrative growth area.

PERIODIC MOTOR VEHICLE INSPECTION

Periodic Motor Vehicle Inspection (PMVI) gives an indication of vehicle condition at a particular point in time. Complete and thorough inspections will find virtually all faults in components with a long deterioration span (longer than the interval between two tests). However, there is bound to be the odd inspection which falls below the mark, and major causes of accidents - low tyre pressure, for instance - will of necessity not be ruled out. As regards faults in components with a shorter deterioration span, these will only be found if they happen to be present at the time of testing. If a fault of this kind occurs between tests, it could result in the total failure of the component, possibly resulting in an accident. There is thus no guarantee that a vehicle which has been tested will not develop a fault likely to cause an accident before its next inspection; in this respect the effect of the Periodic Motor Vehicle Inspection is likely to be inadequate. It has been shown in an American

study (Abbene, 1978) that the effect of PMVI on the maintenance condition of vehicles diminishes considerably after four months, whereas the interval between tests can be twelve months or more (Figure 3).
It is not surprising, then, that the effect of PMVI on accident rates, as a number of studies show, is too small to be measured (Abbene, 1978; Reinfurt & Symons, 1974; Crain, 1980). The few studies which indicate that PMVI could have a measurable worthwhile effect (such as Schroer & Peyton, 1976 and 1977) are subject to methodological shortcomings: since they are based on voluntary cooperation by motorists, who can be assumed to have a more than average interest in maintenance and safety. Other studies (such as Hirschberger & Rompe, 1978) are in turn based on these. PMVI does however bring about a slight improvement in the average condition of cars in general (McCutcheon & Sherman, 1969; Eder, 1980).

Logically, there must be a relationship between vehicle condition and road safety; demonstrating this, however, is another matter. A motorist can after all to some extent compensate for vehicle faults by modifying his driving behaviour.

FAULT INDICATION

Fault indication can help improve road safety and reduce the damage resulting from faults, thereby bringing repair costs down. It is already in use, albeit on a limited scale. As well as the standard indicator lights for oil pressure and water temperature, indicators for brake fluid level and brakepad wear are becoming more common, even in basic versions of cheaper models. To judge by the form which fault indicators and other indicating devices take, and the fact that they are only included in luxury versions, it would seem that designers are more concerned with appearance than safety precautions. Whether these "Christmas Trees" have any practical value is questionable. Take, for example, open door indicators: a glance around the vehicle is quite sufficient.

If fault indicators are to be useful, the following points must be taken into consideration. First we must ascertain what components contribute to accidents; of particular importance are those which have a short deterioration span and are subject to faults which are difficult to detect. We then need to ascertain what caused the failure of a part, and whether timely indication could have prevented it. It also needs to be decided whether the indication should be given while the vehicle is in motion, stationary or under inspection. If the information is presented while the vehicle is in motion, it is important not to distract the drivers attention unnecessarily. It must also be ascertained how drivers react to fault indications.

RELATIVE IMPORTANCE OF FAULTS

Components which have contributed to accidents can be classified according to their relative importance on the basis of American and German accident data (Treat & Joscelyn, 1973; Treat e.a., 1977, DEKRA, 1977, 1981, 1983) (See Table).

Component/fault	Fault indication
1. Brake imbalances	instrument panel and elsewhere
2. Tire tread too shallow	elsewhere
3. Low tire pressure	instrument panel
4. Steering wheel play	elsewhere
5. Worn brake linings	instrument panel and elsewhere
6. Poor brake lights	instrument panel
7. Condition of steering linkage	elsewhere
8. Brake fluid leak	instrument panel and elsewhere
9. Oil/grease leakage into brakes (drums)	(avoid problem at design stage)
10. Faulty brake lights	instrument panel

The behaviour of a vehicle is also strongly influenced by brake imbalances and the condition of the shock absorbers (Heldt & Burke, 1977).

The components listed are the most important ones as regards fault indication. A number of other components can present an immediate danger to road safety in the event of failure, e.g. wheel and axle mountings and brake pipes and hoses in poor condition. These problems have to be obviated at the design stage or by means of preventive measures, e.g. locking devices or protection against corrosion.

The frequency of faults was found to be particularly high in the case of tyres. Here again design features could be a solution, e.g. tyre-rim combinations which enable the vehicle to be driven even with a flat tyre.

SELECTION

Components which require fault indicators can be selected on the basis of the considerations mentioned. Logically, instrument panel fault indicators are recommended where the deterioration span of components is short; otherwise the indicators can be placed elsewhere. From the road safety point of view the following warnings should be given on the instrument panel:

1. brake faults
2. tyre pressure
3. brake light faults
4. brake fluid level/leaks
5. worn brake linings

Nos 1, 3 and 5 are efficient under American conditions from the cost-benefit point of view (Heldt & Burke, 1977). Nos 1 and 2 are not yet in use, the others not in general use. The technology exists, however, and is on the market. Apart from 5, which need only be operational on starting, all of them should be operational when the vehicle is in motion. Indicators for other vehicle lighting systems could be added to the list.

Other important points: how are motorists likely to react if a fault is indicated; how can fault indicators be made to work reliably, especially in older vehicles; and are manufacturers prepared to introduce them and consumers to buy them (depending on availability).

CONCLUSION

We have seen that there are enough ways of preventing faults which are likely to cause accidents. The point, however, is whether owners can be persuaded to maintain their vehicles so as to minimize faults. So far governments have tried to oblige them to do so, for instance by means of large-scale testing schemes, but to little effect. It is more worthwhile to look at the maintenance behaviour of owners and make it easy for them to do their own simple inspections. It is not unreasonable, after all, to assume that the vast majority of owners are not likely to take a vehicle out on the road if it has faults which are potentially dangerous or could cause inconvenience en route; but they have to be aware that something is wrong, even if they are not technically-minded. More consideration needs to be given to a combination of measures, viz. fault indication and PMVI. Fault indicators give a warning when something goes wrong, and PMVI provides an opportunity for the vehicle to be inspected and for the fault indication system to be tested. Manufacturers must, however, be prepared to offer fault indicators with their products. The costs need not be high, and not only would road safety be improved but repair costs would also be reduced, since the expense of repairing subsequent damage is eliminated.

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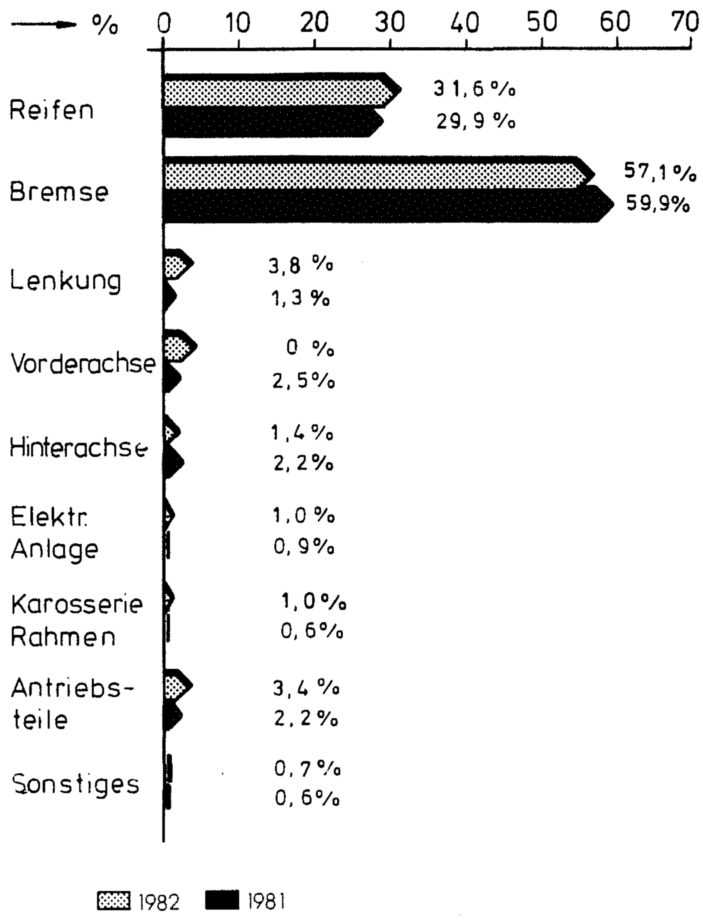

Figure 1. Accident causative defects (Source: DEKRA, 1982)

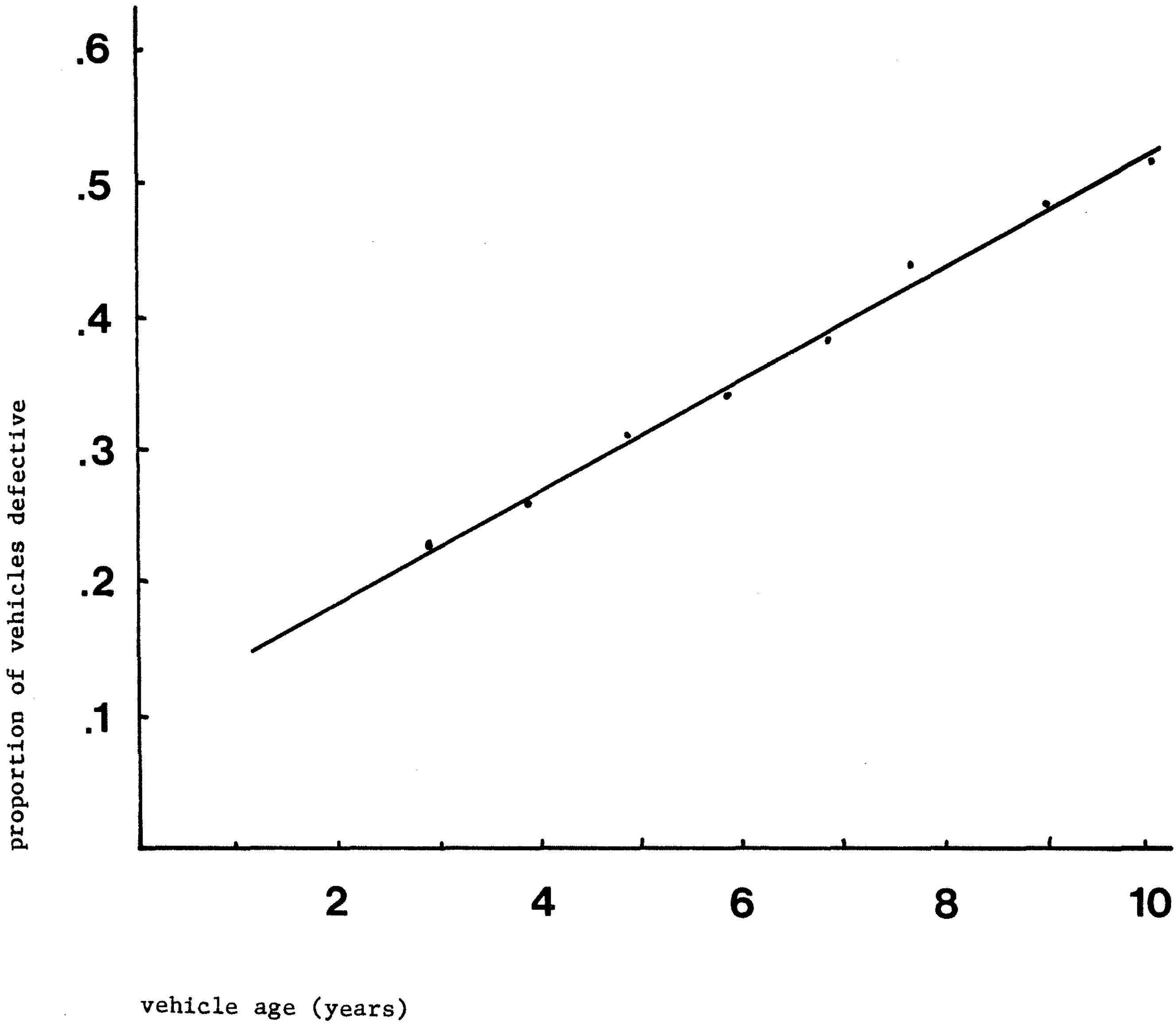

Figure 2. Vehicle age versus defects (Source: Abbene, 1978)

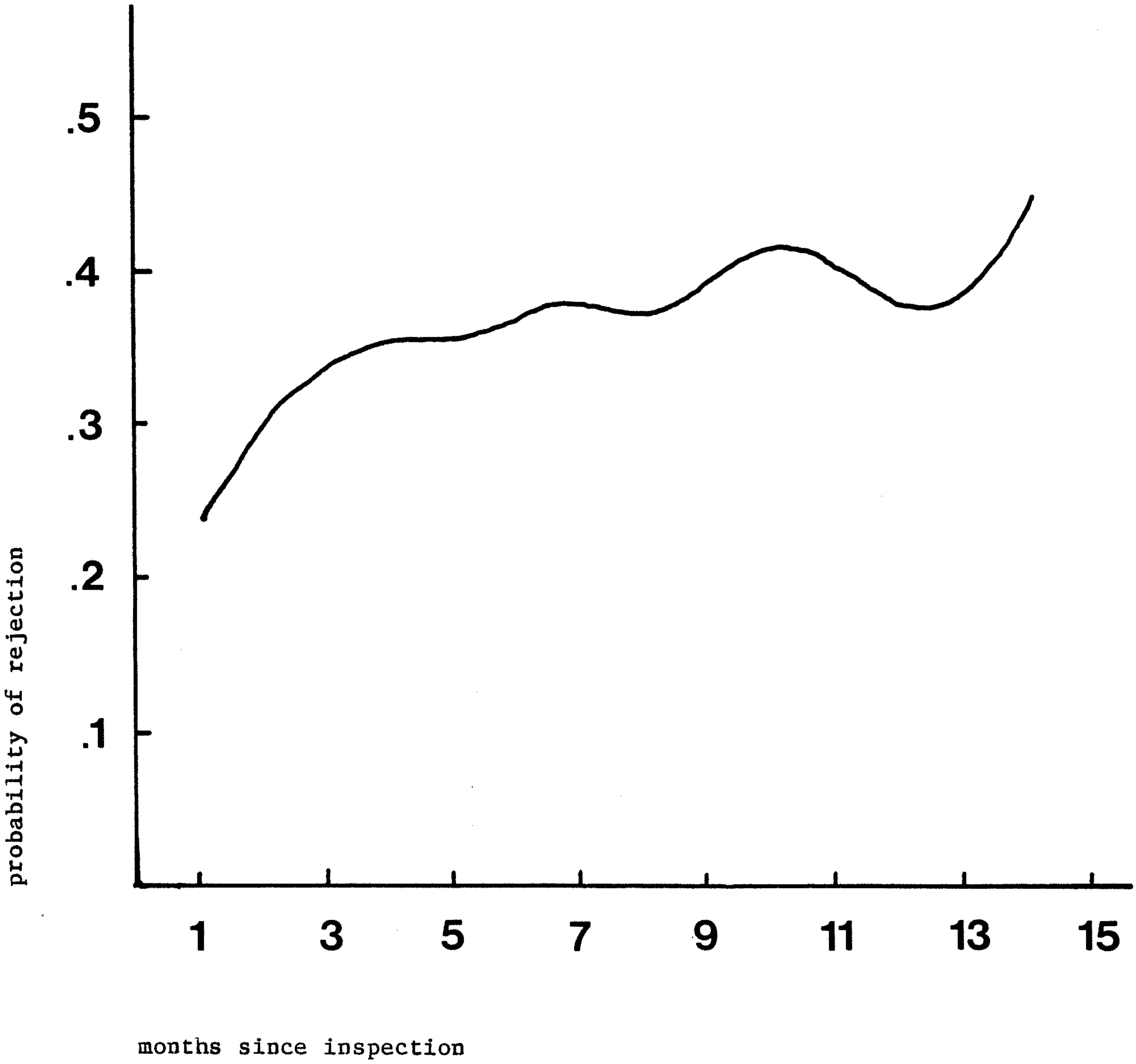

Figure 3. Time since last inspection versus probability of rejection (Source: Abbene, 1978)