# Noise Control in Rapid Transit System, Toronto Transportation Commission

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Technical Note 102

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TECHNICAL NOTE NO. 102

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Approved by Robert F. Legget Date July 4, 1951

Subject: Noise Control in Rapid Transit System
Toronto Transportation Commission.

Since the subway cars proposed for the new TTC subway are of the modern PCC design it was anticipated that they would be pleasantly quiet, compared to most other subway systems. However, cars of this same type, now in use on a new line of the Chicago Transit Authority, failed to confirm this supposition. Although significantly quieter than the older subway cars, the new cars are still uncomfortably noisy. A more precise evaluation might be that it is practically impossible to hold a conversation when travelling in the new cars (with windows open) or when standing in a station while a train approaches.

At the request of Deleuw, Cather & Co., the Armour Research Foundation of Chicago made noise measurements on the Chicago subway and prepared a report discussing the acoustic treatment of the TTC subway (1). This report was discussed at a conference held at the offices of Deleuw, Cather & Co. on June 25th, attended by Messrs. Deleuw and Watson of that firm, Hardy and Bonvallet of Armour Research Foundation, and the writer. Details of a suitable acoustic treatment were worked out as discussed below.

2. Chicago Subway Data

The report may be summarized as follows:- The new Chicago Transit Authority line employs cars similar to those planned for the TTC subway. Since the line is partly subway and partly elevated, it was possible to make noise measurements for two conditions, corresponding to untreated subway and open air. (Actually vibrations set up in the elevated structure make it somewhat noisier than surface conditions would be, but it represents quite tolerable noise conditions.) A calculation was then made of the noise reduction which would be obtained in the TTC subway with an acoustic absorption treatment which had tentatively been proposed. Assuming that without treatment the noise level in the TTC subway would be the same as in the Chicago subway, the effect of the reduction in the station areas would be as indicated below. (The data is for noise on the station platform; similar results obtain for noise in the moving train between stations.)

| | Loudness |
|---|---|
| Untreated (Chicago subway station | 290 Sones |
| Treated (TTC) subway station | 230 " |
| Chicago Elecated station | 180 " |

Sone units are arithmetic, so that it may be said that the proposed treatment will provide about half the maximum reduction obtainable with absorption treatment. Thus the report indicates that the proposed acoustic treatment, while not the ultimate, would make a significant improvement in the comfort of the subway.

It was the consensus at the meeting that acoustic absorption treatment of the order considered in the tentative design should be installed in the TTC subway. Details of a practical installation are outlined in Appendix A.

3. Noise Reduction at the Source

There was considerable discussion of the possibility of reducing the noise at the source. However, there was not sufficient data to indicate whether this could readily be done. Mr. Deleuw stated his opinion that any step which would increase the cost of the cars materially would not likely be entertained.

Mr. Hardy described the noise as having a fairly definite range of pitch, at 300-400 cycles per second. It was conjectured that this might possibly be gear noise. However, subsequent observations led the writer to believe that the noise was due to a resonant vibration of some component, for the pitch of the sound does not alter with speed, as would be expected with what is usually called gear noise. It was the writer's guess that the pitch is determined by vibrations in the wheel rim and that they are excited by the rim rolling or rubbing on the rail. If this is so, it will probably not be feasible to reduce the noise at the source except by drastic changes (e.g. use of rubber-tired wheels, as suggested recently by Mr. Tryhorn of the TTC). This conclusion is confirmed by published information on the PCC car development (2).

It is possible that a significant portion of the noise is radiated by the rail. In this case coating the rail, along the lines suggested by Mr. Tryhorn, might be effective. This problem might well be studied, first with a simple small-scale experiment, and then on an actual stretch of track, perhaps utilizing a PCC street-car, which produces similar noise. However, this is an experiment with small probability of success, and it is believed that the prescribed acoustic treatment on the subway walls is the first essential. If a significant reduction is obtainable by the rail treatment it can probably be applied after the subway is in operation.

4. British Experience in Subway Quieting

It is of interest to note that the same problem was investigated by the London Passenger Transport Board (England) (3). After some preliminary experimenting in sections of the subway, a sound absorption treatment similar acoustically to our present proposal was adopted and plans were made for general application of the treatment throughout the London Tubes. There is, therefore, this experimental verification that the treatment is effective.

In the London report considerable emphasis was placed on the danger of flash fire arising from a collection of dust on a rough surfaced material. The treatment recommended above should be considered critically from this point of view. It was Dr. Hardy's opinion that the facing material prescribed above could stand repeated cleanings.

It was also found in the London investigation that the condition of the rails was of great importance. Continuous welded-joint rails were found much quieter than conventional butt-jointed rails. In this respect the TTC subway will be superior to the Chicago subway, where conventional rail joints are used.

References

(1) Acoustic Tests and Design Data for Proposed New Subway.
Report No. 1, Test No. 6899A, June 4, 1951.
Armour Research Foundation.

(2) Vibration of Rail and Road Vehicles.
by B.S. Cain, Pitman Publishing Corp., 1940.

(3) Silencing London's Tubes.
John S. Trevor, Bull. Int. Railway Congress Assoc.,
pp. 475-479, May, 1939.

## APPENDIX A

### Recommended Sound Absorption Treatment - TTC Subway

1. Construction of Absorption Units

The required sound absorption may be obtained with a thick layer of TW-F Fiberglas (or rock-wool equivalent). At the meeting, Dr. Hardy suggested a 4" thickness, compressed to about $3\frac{1}{2}$" on installation. However, the original report recommended a 3" thickness, and a glance at a Fiberglas catalogue suggests that this is the maximum standard thickness of TW-F Fiberglas. It is the writer's opinion that 3" material, in maximum density obtainable, would be adequate if 4" material is not readily available.

The exposed face of the absorption material should be covered with Fiberglas cloth. This will not impair the sound absorption properties of the material and will provide a durable surface, which can be cleaned. The whole unit should be restrained with chicken wire or similar material anchored on any convenient framing material. The framing should be slightly narrower than the thickness of the absorption material so that it can be compressed slightly and thus firmly supported.

In selecting framing material and other hardware, a rust-proof, moisture-resistant construction should be used. It was suggested that the chicken wire might be made of aluminum. Since the fiberglas is an effective thermal insulant there will be no condensation on the wall actually covered by material, but there may be a flow of water from the upper wall. It was suggested to me that the top edge of the framing might be made so that water could drip off a projecting edge.

2. Location of Material

It is desirable to mount the material between track level and window level, since the noise originates at wheel level. The prescribed assembly will not be very handsome, and it is therefore suggested that it be kept below window height.

Since the area on the outer wall is occupied by a walk-way for maintenance staff, any reduction in clearance was deemed undesirable. However, the lower part of the middle partition seems free of any such restriction, aside from occasional power cable installations. It was recommended that a four-foot strip of absorption treatment be applied on this surface, the exact location to be determined by considering power cable and other details. Of course the treatment need not extend across the wall openings.

In station areas the surfaces under the platform overhang form a suitable site. It was recommended that both horizontal and vertical faces of this region be covered as completely as possible.