CF-105 NOISE

REPORT ON VISITS

TO

WADC AND PRATT & WHITNEY

6-7 March and 13-14 March 1956

LOG/105/25

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1. INTRODUCTION

Concern has been expressed by the Company and by the RCAF concerning the noise problem to be expected during CF-105 flight and maintenance operations.

The problem concerns:

(1) The Company, with respect to

(a) The effect on company employees directly concerned with flight and maintenance of the CF-105. This might affect the safety of the aircraft.

(b) The effect on company employees engaged in other work.

(c) The effect on neighboring habitations, such as the Airport, Race course, Malton, Weston etc. This might precipitate legal actions.

(2) The RCAF, regarding

(a) The effect on flight crew and maintenance crews.

(b) The effect on other personnel and families on the air-base.

(c) The effect on neighboring communities.

Extremely high noise levels will be generated by the CF-105,

(a) During maintenance operations requiring engines to be operated at full power with afterburner lit, on the ground.

(b) During take-off and climb.

(c) During trans-sonic and supersonic level flight, (sonic booms).

At the request of the Chairman of the RCAF Sub-Committee for CF-105 Readiness, Dr. Neely of the Defence Research Board Medical Laboratories at Toronto is now engaged in preparing noise intensity charts at ground level during CF-105 combat mission take-off and climb. Aircraft performance data for the preparation of these charts have been supplied by AVRO. On receipt of these charts, S/L Markham will submit these together with a report to the Chief of the Air Staff.

In order to gather information on the subject, the logistics engineer in conjunction with the chairman of the RCAF Sub-Committee for readiness (CF-105), arranged visits to the Coordinator of the USAF Noise and Vibration Control Programme at WADC and to the noise specialists at the Pratt and Whitney Company.

The Canadian party to WADC consisted of:

S/L P. de L. Markham, DMEng, AFHQ, chairman CF-105 Readiness Sub-Committee
Dr. K.K. Neely, Chief Sonics Group, Defence Research Medical Laboratories
Dr. P.E. Ireland, U. of T., D.R.B. Panel on Auditory Problems
Dr. J. Scott, U. of T. D.R.B. Panel on Auditory Problems
J.P. Booth, Logistics Engineer, AVRO.

The party to Pratt and Whitney consisted of:

S/L P. de L. Markham
Dr. K.K. Neely
Dr. J. Scott
Dr. G. Thiessen, N.R.C., D.R.B. Panel on Auditory Problems
J.P. Booth.

A representative from the RCAF Medical Branch, W/C J. Powell, Officer Commanding, CME/IAM, had been invited but did not attend. This default gave rise to criticism from the DRB members of the party.

2. W.A.D.C. TRIP

We were received by Col. J. Bollerud of the Aero Medical Labs. and had discussions with Dr. H.O. Parrack, Dr. H.E. von Gierke and Capt. Hanson.

2.1 Expected Noise Level

We enquired what the expected maximum overall sound pressure level would be for our engines. Dr. von Gierke estimated this to be of the order of 152 decibels maximum at a distance of 100 feet. This is less than the tentative figure of 160 decibels estimated by the writer but is still within the danger zone for human exposure. The quoted noise level is an estimate and data on mass flow, exhaust-temperature and nozzle area are required in order to make a more accurate forecast. They estimated a 7 to 10 decibel reduction for running the engines at military rating without afterburners. It was suggested by WADC that Orenda Engines Ltd. carry out comparative noise level measurements on an Orenda and on a PS-13 in a test cell in order to definitely establish free field noise levels.

2.2 Noise Level versus Distance

A commonly accepted rule is a decrease of 6 decibels in the noise level per doubling of distance from the noise source or conversily an increase of 6 decibels per halving of distance.

2.3 Noise Level versus Aircraft Speed

It has been found experimentally that speed slightly decreases the noise level and that the point at which noise is a maximum moves forward relative to the source as its forward speed is increased.

For instance it has been found, on a F-100 aircraft, that under static conditions the maximum sound pressure level was 128 decibels at a point aft of the plane of the jet nozzle. At a speed of .85M the maximum sound pressure level was 125 decibels at a point forward of the plane of the jet nozzle, while at the point aft of the nozzle plane the noise had reduced to 113 decibels.

2.4 Noise effect on Aircraft Structure

We were warned that the effect of high noise levels on aircraft structure is detrimental and shows up in the form of cracked panels, loose rivets etc.

We are fortunate that on the CF-105 the main load carrying structure is ahead of the exhaust nozzles. However, the control surfaces and the aft sting structure will be in a very high noise field and need to be stressed accordingly.

2.5 Noise Effect on Man

Selected unprotected personnel can perform manual tasks in a noise level of 100 decibels for a period of 8 hours continuous. Unprotected personnel can withstand a noise level of 135 decibels for no longer than 10 seconds. It was confirmed that no form of ear protector will protect man at a noise level of 150 decibels. The effects of exposure to greater than 140 decibels may cause hearing loss, damage to tissues, interference with orientation and coordination, fatigue, loss of sleep and psychosomatic or neuropsychiatric symptons.

Refer WADC report TN-55-355: Criteria for short time exposure of personnel to high intensity jet aircraft noise; September 1955.

2.6 Aircraft Maintenance

To trim the controls, engines require to be run up at full throttle with afterburners lit. It was established that under these conditions, maintenance personnel (even fully protected) cannot safely approach the CF-105 engines. It was WADC's opinion that an engine run-up facility would be required and that engine trimming would have to be carried out by means of remote control. This could be done from the aircraft cockpit or from an insulated test room. Intake silencing was not considered essential.

ACF-2 We have been told no such requirement

Mention was made of a jet exhaust silencer, developed by Pratt and Whitney, which appeared very promising for engines not fitted with afterburners. This will be discussed further in this report.

2.7 Sonic Booms

Brief mention was made of this phenomenum. Dr. von Gierke expressed the opinion that at our low level mission speed of .92M just prior to climb, minor sonic booms could be expected. Our attention was called to the fact that during low level supersonic testing with a F-100, extensive damage was caused on surrounding property and factory buildings at North American.

3. PRATT AND WHITNEY TRIP

We had discussion regarding engine noise with:

Messrs. John M. Tyler
Krieghoff
Funk
Moores
Seaman
Sullivan

In the afternoon we discussed the health and safety programme at P & W with Dr. J. Gallivan (chief medical officer) and Dr. Wheeler (supervisor special health service).

We also inspected the engine run-up cells with sound abatement structures and witnessed a free field engine run-up of a J-57 engine with and without a jet exhaust silencer device.

3.1 Expected Noise Level

We again enquired what the expected maximum overall sound pressure level would be for the J-75 engine with afterburner. We were told that at 22,500 lb. thrust they expected this to be of the order of 140 decibels. The general feeling of our party was that this information should be accepted with a great deal of scepticism in view of what WADC had told us previously. P & W have done no noise level measurements on the J-75 yet. They have however done and are still actively engaged in a study of jet engine noise with the object of establishing means for predicting the noise of proposed jet engines and means for silencing jet exhausts. They supplied us with a report which gives a theoretical method for estimating the noise pressure level of a jet engine. In order to carry out this calculation, accurate values for thrust, air mass flow and nozzle area are required.

3.2 Engine Run Up Facilities

Pratt and Whitney employ all the well known makes of silencing equipment in their 100 test cells. These cells are used only for checking out bare engines with or without afterburners. Such a cell costs about $250,000. For the J-75 engine with afterburner they recommend so-called "duro-stack" silencing equipment made by Industrial Acoustics Inc. of New York in preference to the equipment made by Industrial Sound Control and others. "Duro-Stack" consists essentially of a baffled chamber, the baffles being perforated boiler plate; 850 gallon per minute of water is required to be injected into the exhaust flow in order to cool the stack when afterburner is lit. We saw such an installation in operation with a J-57 engine with afterburner; the water is injected immediately aft of the afterburner nozzle and turns instantly to steam. "Duro-Stack" equipment has been installed at North American Aviation Inc., Republic Aviation and at W.A.D.C. The main advantage claimed for "duro-stack" is that it will last longer than equipment made by Industrial Sound Control and others, when using afterburning engines.

Apparently Industrial Acoustics Inc. sells "duro-stack" silencers for $25,000 each. These then require installation into a facility.

3.3 Engine Noise Suppressors

The main effort at Pratt and Whitney in the noise field is directed towards finding means of suppressing jet noise at the source, for engines installed in commercial air liners. The New York Port Authority has ruled that it will not allow jet liners to operate from its airports unless their noise is no higher than that from propeller driven aircraft. P & W believes that this criterion can be met.

We were given an outdoor demonstration of their noise suppressor as fitted to a J-57 engine without afterburner. This was very impressive; a noise reduction of about 35 decibels being recorded with this very simple device. This suppressor is described in P & W report PWA Inst. 469, "A Jet Exhaust Silencer". It consists essentially of a perforated 1/16" sheet steel tube closed at the far end by a perforated steel cone. The perforations consist of holes .085 inch diameter and spaced 3 diameters apart. For the J-57 engine this so-called "basket" is 2 feet diameter and 6 feet long, it weighs 75 lb. and costs $2,500. The total hole area is 40 to 50% greater than the nozzle area. The open end of the "basket" is attached to the engine exhaust nozzle by means of an ordinary quick release clamp.

The design principle of this device is to break the main jet up into a very large number of tiny jets. This shifts the sound spectrum into frequency ranges which are beyond audible. The demonstration we witnessed confirmed this. Wearing ear protectors we were able to closely approach a J-57 engine running at full throttle (10,000 lb. thrust) and

fitted with this silencer. Without the silencer, however, we felt distinctly uncomfortable at a distance of 100 ft. from the exhaust nozzle, even while wearing the ear protectors; one could feel the buffeting on ones body (I was wearing a thick overcoat). Without ear protection one did not want to remain in that spot for more than 20 - 30 seconds. The maximum sound pressure levels recorded during that run were 132 decibels at 150 ft. without the silencer and about 100 decibels with the silencer.

Obviously, this particular device destroys partically all of the engine thrust but we were told that it had no effect on engine trim settings. The silencer perforated area may be adjusted so that at a given operating condition, say take-off thrust, the engine operates the same with the silencer as without. At lower airflow the combination of nozzle and silencer act like a nozzle of smaller diameter. However, this may be satisfactory for ground running purposes.

Unfortunately the device in its present form is unsuitable for fitting to aircraft with afterburner engines, because of (a) the high temperature, (b) it would destroy the nozzle ejector effect required for cooling the afterburner in the aircraft. Pratt and Whitney's present effort is solely directed towards developing this device as a flight silencer to recuperate most of the thrust and for installation on jet air liners fitted with non-afterburning engines. By angling the tiny jets rearward they are confident of achieving a satisfactory thrust and they are also working on making the basket collapsible like a picnic drinking cup. By this method the tail cone and silencer sleeves would be extended rearward during take-off and climb, but for altitude cruising the silencer would be retracted and inactive.

In view of the astonishing results witnessed by us when employing this developmental basket silencer, I would recommend that either AVRO or ORENDA do a design study on a silencer suitable for afterburner operation and based on its basic design principle. In view of the tremendous cost savings which might be achieved as compared with run-up facilities costing 100 times as much, I feel that such a study would be very worthwhile to the RCAF and ourselves. We also know that WADC are very interested in this device.

3.4 Engine Intake Silencers

Pratt and Whitney fit bulky intake silencers to their engines tested in the open. These are crude affairs weighing as much as 1000 lb.

Intake noise is mostly in the high frequency band, being generated by the first stage stator and compressor blades. High frequency noise fields are directionally concentrated and also attenuate rapidly with distance. For this reason Pratt and Whitney suggested that we try

running up our aircraft without intake silencers initially and see how bad the noise level from this source is, before spending money on such equipment.

3.5 Health and Safety Programme

The medical people in our party were of course especially interested in this. The writer of this report, not being conversant with the medical aspect, does not feel competent to discuss this subject in any detail. However, it should be stated that I was very impressed by the thorough way in which that Company had organized its health department. With reference to "noise", all personnel subjected to a noise level of 100 decibels are given a 60 day check-over and an audiogram is taken. Personnel subjected to noise levels in excess of 100 decibels receive additional check-ups. In addition all prospective employees have an audiogram taken prior to placement.

I have included in this report two medical record cards which may be of interest to our Industrial Relations people. Number One is the Functional Capacity Record of each new employee. The data on this record card are compared with Physical Demand Records of various jobs before the employee is placed in a certain job. Number Two is the Audiogram record card mentioned above.

I recommend that our personnel and medical people take the necessary steps to deal with this health problem before it is upon us; especially with regard to flight test personnel who will be directly affected. The DRML people and members of the panel on auditory problems have impressed upon me the need of a planned programme in this regard and they have very kindly offered any assistance we may require. Dr. Ireland in particular was very keen on having a chat with members of our management on the subject.

4. RECOMMENDATIONS

(1) Plant Engineering and Logistics Office to contact the Industrial Acoustics Company of New York to discuss their silencer equipment with a view to buying same for an aircraft run-up facility at our plant.

(2) A design study to be started as soon as possible by AVRO in conjunction with ORENDA on a ground silencer for the CF-105 based on the Pratt and Whitney design principle. I believe that the RCAF might give us a contract for this.

(3) A report to be prepared by AVRO giving full particulars of engine thrust, mass flow, exhaust temperature, nozzle area during take-off and climb of various design missions for the CF-105 fitted with (a) J-75 engines and (b) PS-13 engines. This report to include

estimated maximum noise levels based on Pratt and Whitney's method of calculating same.

(4) This report to be sent to WADC for checking expected noise levels. (Dr. Parrack has expressed his willingness to do this.)

(5) Dr. Ireland and Dr. Neely to be invited to AVRO for discussions with our management on the effect of noise on CF-105 maintenance personnel and measures to be taken.

5. REFERENCES

(1) WADC report TN-55-355, Criteria for short time exposure of personnel to high intensity jet aircraft noise, September 1955.

(2) Pratt and Whitney, General Turbine Information Letter No. 14.

(3) Pratt and Whitney, Report No. PWA Inst. 451, Jet Noise.

(4) Pratt and Whitney, Report No. PWA Inst. 469, A Jet Exhaust Silencer.

ASC AUDIOGRAM

BY _____

NAME _____ AGE ____ DATE _____

ADDRESS _____

Loss in Decibels	64	128	256	512	1024	1448	2048	2896	4096	5792	8192	11584
-10												
NORMAL 0												
10				.2	.3		.4		.1			
20				1.1	2.1		2.9		.9			
30				2.6	5.4		7.3		2.7			
40				4.9	10.2		12.9		5.0			
50				7.9	15.7		22.4		8.0			
60				11.3	21.5		28.0		11.2			
70				13.8	25.5		32.2		13.5			
80				14.8	28.8		35.8		14.6			
90				15.0	29.9		39.2		14.9			
100					30.0		40.0		15.0			

(SHADED SECTION INDICATES CRITICAL AREA OF SPEECH INTERPRETATION)

AUDIOMETER SALES CORPORATION
MINNEAPOLIS 1, MINN.

FORM 154 25 M 10-53

PERCENTAGE HEARING LOSS		
FREQUENCY	RT. EAR	LEFT EAR
512		
1024		
2048		
4096		
TOTAL % EACH EAR		
BETTER EAR % TOTAL x 7		
ADD POOR EAR TOTAL		
SUM OF BOTH		
DIVIDED BY 8 EQUALS % LOSS IN BOTH EARS		

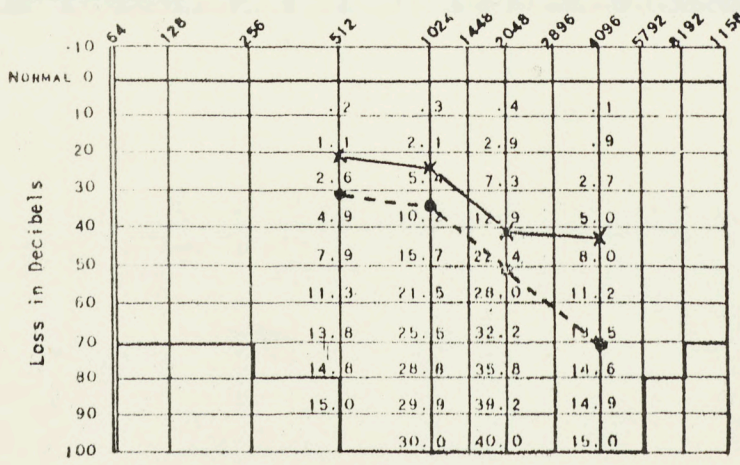
DB SPEECH LOSS		FREE FIELD THRESHOLD	
Left Ear	Right Ear	Aided	Unaided

CODE		
EAR	AIR	BONE
LEFT	X	<
RIGHT	●	>

DIRECTIONS FOR OBTAINING % LOSS IN EACH EAR AND FOR FIGURING COMBINED LOSS IN TWO EARS

1. Record Pure Tone Threshold Loss on audiogram using code symbols indicated.
2. Mark % loss of each frequency in Hearing Loss Chart (use threshold readings).
3. Add figures in the four frequencies for total % loss in each ear.
4. To obtain % loss binaurally (both ears) multiply the total % loss of the better ear by 7.
5. Add the total % loss of the poor ear.
6. Divide the sum of the two by 8. This is the % loss of the two ears combined.

EXAMPLE:



PERCENTAGE HEARING LOSS		
FREQUENCY	RT. EAR	LEFT EAR
512	2.6	1.1
1024	5.4	2.1
2048	22.4	12.9
4096	13.5	5.0
TOTAL % EACH EAR	43.9	21.1
BETTER EAR % TOTAL x 7		147.7
ADD POOR EAR TOTAL		43.9
SUM OF BOTH		191.6
DIVIDED BY 8 EQUALS % LOSS IN BOTH EARS		23.9

PWA F-149A REV. 5-54

NAME	CLOCK	DEPT. and SHIFT	JOB CODE	OCCUPATION

FUNCTIONAL CAPACITY R

HEALTH and SAFETY SECTION of the PERSONNEL DE

EXPLANATION OF ENTRIES

NUMBER OR FRACTION	INDICATES MAXIMUM HOURS PER 8 HOUR DAY IN WHICH EMPLOYEE IS CAPABLE OF PERFORMING THE PHYSICAL FACTOR INVOLVED.

PHYSICAL FACTORS

8	1	TOTAL HOURS ON FEET			ON FEET
8	2	STANDING			
8	3	WALKING—Level surfaces			
8	4	CLIMBING—Stairs, ramps			
	5	11–20 lbs.	FLOOR TO FOUR FEET	TOTAL EFFORT IN LIFTING CARRYING PUSHING PULLING	WEIGHT EFFORT
	6	21–35 lbs.			
	7	36–50 lbs.			
	8	51–65 lbs.			
	9	66–80 lbs.			
	10	11–20 lbs.	FOUR TO SEVEN FEET		
	11	21–35 lbs.			
	12	36–50 lbs.			
	13	51–65 lbs.			
	14	21–35 lbs.	BENCH TO BENCH		
	15	36–50 lbs.			
	16	51–65 lbs.			
	17	66–80 lbs.			
	18	IF "X", SEE REMARKS			
8	19	BACK and HIP BENDING (30°–90°)			BODY
8	20	CRAWLING, LYING			
8	21	CROUCHING, SQUATTING			
8	22	SITTING			
8	23	Right	FINGERING (Pinching or Manual Dexterity)		HANDS
8	24	Left			
8	25	Right	HANDLING (Grasping or Coarse Hand Motion)		
8	26	Left			
8	27	Right	30°–90° from Straight	ELBOW BENDING	ARMS
8	28	Left			
8	29	Right	91°–120° from Straight		
8	30	Left			
8	31	Right	Above Shoulders	REACHING	
8	32	Left			
8	33	Right	Below Shoulders		
8	34	Left			
8	35	Right	30°–90° from Straight	KNEE BENDING	LEGS
8	36	Left			
	37	Right	91°–120° from Straight		
	38	Left			

REMARKS

ITEM NO.	

TYPE EXAM.

CK	DEPT. and SHIFT	JOB CODE	OCCUPATION	DATE OF BIRTH	SEX	TYPE OF EXAM.	DATE OF EXAM.	M	S	I

FUNCTIONAL CAPACITY RECORD

HEALTH and SAFETY SECTION of the PERSONNEL DEPARTMENT

REMARKS

EXPLANATION OF ENTRIES

X	EMPLOYEE HAS CAPACITY FOR THE SENSORY OR EXPOSURE FACTOR SO MARKED.
O	EMPLOYEE DOES NOT HAVE CAPACITY FOR THE SENSORY OR EXPOSURE FACTOR SO MARKED.

SENSORY and EXPOSURE FACTORS

SPECIAL SENSES	EYE-SIGHT	FAR RATING	A	39	X
			B	40	X
			C	41	X
			D	42	X
		NEAR RATING	A	43	X
			B	44	X
			C	45	X
			D	46	X
	THREE DIMENSION VISION			47	X
	COLOR VISION			48	X
	TALKING			49	X
	HEARING			50	X
ACCIDENT EXPOSURES	OPERATING EXPOSURES	POWER VEHICLES		51	X
		POWER HOISTS		52	X
		EXPOSED MACHINES		53	X
		POWER HAND TOOLS		54	X
		TRICYCLES		55	X
	WALKING EXPOSURES	SLIPPERY SURFACES		56	X
		HOLES and PITS		57	X
		OBSTRUCTIONS		58	X
	ELEVATIONS	LADDERS		59	X
		UNGUARDED (over 5 ft.)		60	X
SKIN EXPOS	PRIMARY IRRITANTS (acids, alkalis, etc.)			61	X
	SENSITIZERS (synthetic resins, etc.)			62	X
	DEFATTERS (solvents, strippers, etc.)			63	X
	SOAPS (soluble cutting oils, soaps, etc.)			64	X
	FOLLIC. IRR. (insol. oils, greases, etc.)			65	X
ENVIRONMENT	TEMPERATURE	HIGH (10° above shop)		66	X
		LOW (10° below shop)		67	X
		RAPID CH'NG'S (30° ±)		68	X
		COLD WATER		69	X
	NOISE	80–90 DECIBELS		70	X
		91–100 DECIBELS		71	X
		OVER 100 DECIBELS		72	X
	AIR CONTAMINANTS	Dusts, Fumes		73	X
		Mists, Gases, Vapors		74	X
	RADIATION	X-ray, Gamma Rays, etc.		75	
		Ultra-Violet, Infra-Red, etc.		76	

EXAM.

EXAMINING PHYSICIAN

LOG 105-25

08891