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Technical Report

Particulate Measurement - Motorcycle Test Results

by

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NOTICE

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Summary

Particulate testing has been successfully completed on two different two-stroke powered motorcycles. The results indicate that the amount of particulate material produced by motorcycles is no greater than that from light-duty diesel automobiles. This conclusion is based on the fact that of the two motorcycles tested, the higher emitter (Kawasaki KE-100) produced approximately the same amount of particulate material over the FTP driving cycle as a Mercedes 300D diesel produces. The amount of particulate produced by the lower emitter (Yamaha DT 100) was about one-fourth that of the higher emitter.

Discussion

Experimental tests have been conducted to help determine whether or not motorcycles produce substantial amounts of particulate material. Two motorcycles, a Kawasaki KE-100 (100 cc) and a Yamaha DT-100 (100 cc), were used for these tests. Both were powered by two-stroke engines. Two-stroke powered motorcycles were selected because it was felt that these would produce the highest amount of particulate material and therefore give an indication of the upper bound on the amount of particulate material produced by motorcycles. Presented on the attached table is a summary of the results of this testing. These data indicate that over the FTP cycle, the amount of particulate produced by the Kawasaki KE-100 (higher emitter) is approximately the same as that produced by a Mercedes 300D diesel (i.e., about 0.31 gm/km). The Yamaha DT-100 motorcycle produced about one-fourth the amount of particulate produced by the Kawasaki motorcycle over the same driving cycle. These data form the basis for the statement in the Summary which concluded that the amount of particulate material produced by motorcycles is no greater than that from typical light-duty diesel automobiles.

It should be noted that the repeatability of the measured particulate produced by the Yamaha is fairly poor. This is considered to be due to the fact that this motorcycle was a manual start vehicle and that some difficulty was encountered in starting it (i.e., 8-10 strokes were required for starting). Also, the amount of particulate being collected was comparatively small and hence higher percentage weight differences are calculated for a given weight difference.

Test Procedure

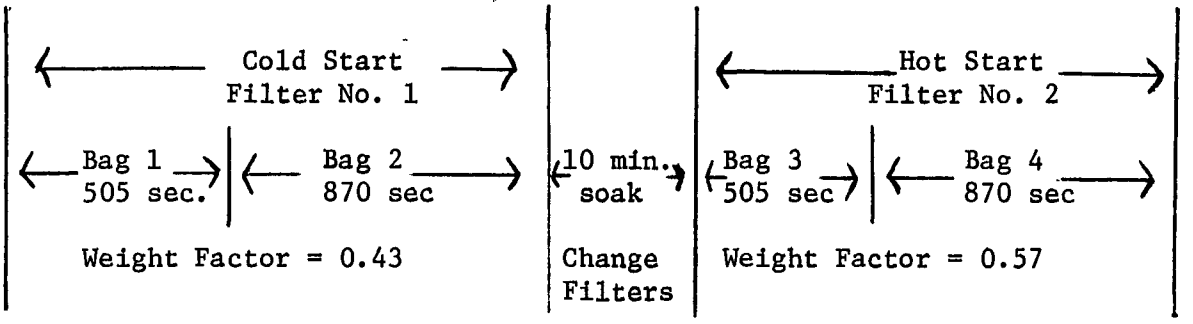
In order to test motorcycles for particulates, an eight inch dilution tunnel was assembled and checked out along with the 20.88 inch roll diameter dynamometer previously used for motorcycles. (Previous particulate testing conducted at EPA (Ann Arbor) has used an 18 inch dilution tunnel.) After successful completion of the assembly and checkout, testing began.

Particulates were collected by isokinetically removing a sample of the diluted exhaust from the tunnel. The sample was then passed through a glass fiber filter which removed all of the particulate material (see attached figure). The weight of the particulate collected is considered to be the net weight difference between the clean filter and the loaded filter. It should be noted that the filter was both pre-conditioned (before test) and post-conditioned (after test) with respect to the water content of the filter. That is, steps were taken to insure that only particulate material, and not water was counted in the net weight of the material.

One other important fact must be mentioned in conjunction with the sample system, and that is the fact that the CVS unit used for this testing was a critical flow venturi type, while the sample probe was a straight through type (i.e., not critical flow). However, the claim that the sample was taken isokinetically is valid because the temperature of the diluted exhaust in the tunnel varied less than 10°F (between 75°F and 85°F) during any test. This temperature difference translates into a one percent error in sample flow rate. This claim is further substantiated by the fact that the measured sample flow and the measured CVS flow indicated that in most cases the sample flow was within five percent of the desired isokinetic flow. (Setting the sample pump to the precise flow rate is considered to be the largest source of error.)

A final comment with respect to the Test Procedure must be made concerning the driving cycle and hot start/cold start filter distinction. Throughout this program, testing was conducted following FTP type procedures, including driving cycle, except for one major modification. This modification was to actually drive out the last 870 seconds of the hot portion of the test (i.e., conduct a 4 bag test). With this modified driving cycle two particulate filter samples were taken in sequence. The first sample was taken during the cold start part of the test (bags

1 and 2) and the second sample was taken during the hot start part of the test (bags 3 and 4). By collecting particulates in this way no assumptions had to be made concerning the amount of particulate produced during the last 870 seconds of the cycle (bag 4). Hence, direct calculation of the FTP weighted mass of particulates could be made. This concept is diagrammed below.

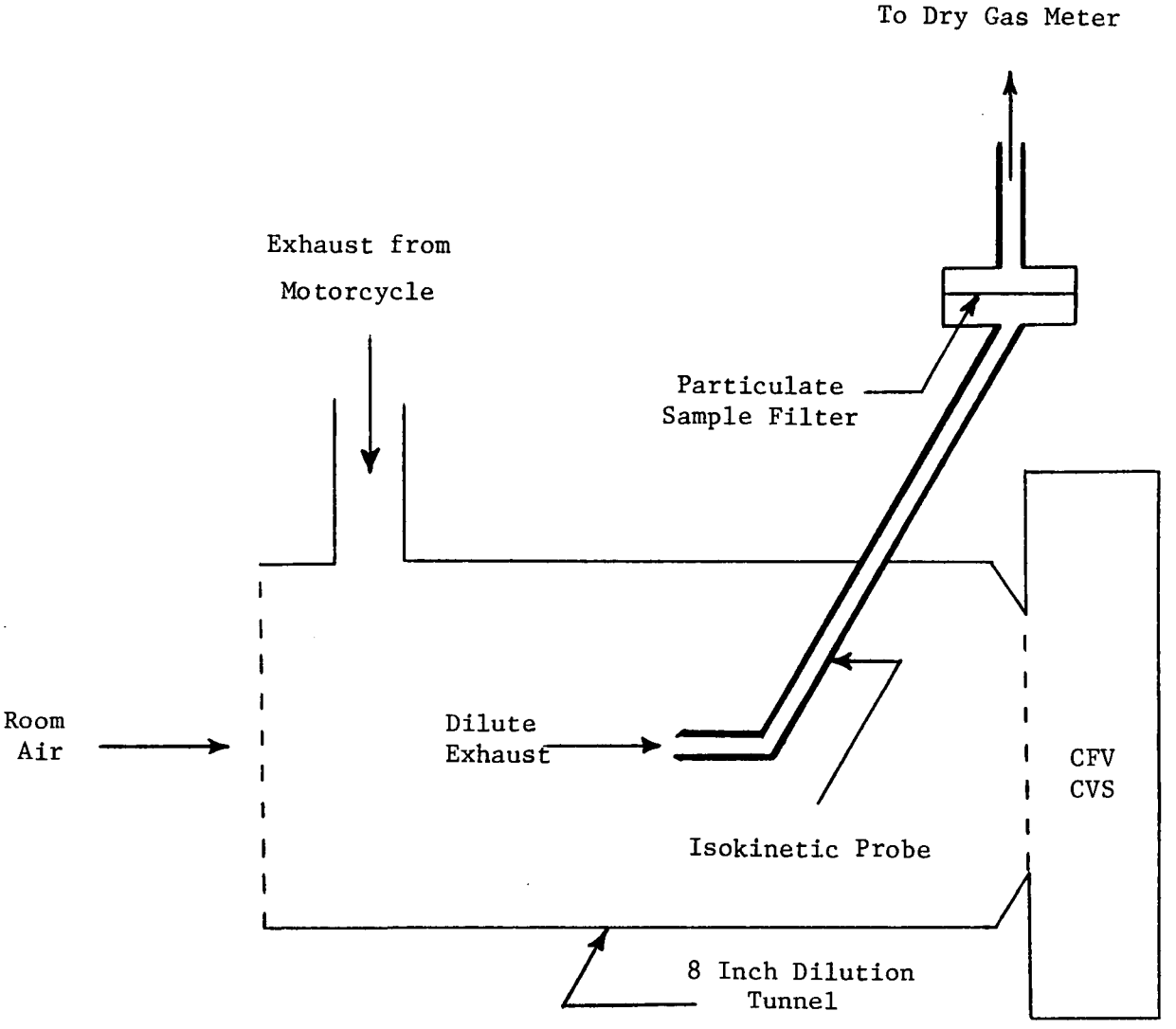


Weighted mass = 0.43 x Net Weight of filter #1 + 0.57 x Net Weight of filter #2

Results

Presented on the attached sheet is a summary of both the gaseous and particulate emissions. The highest particulate level measured from the Kawasaki was 0.353 gm/km, and from the Yamaha 0.095 gm/km. As discussed previously these data form the basis for concluding that the amount of the particlate emissions produced by motorcycles is no greater than from typical light-duty diesel automobiles. For comparison, a Mercedes 300D diesel produces about 0.31 gm/km over the FTP driving cycle, and particulates from other light-duty diesel automobiles have been measured as high as 0.6 gm/km.

Motorcycle Particulate Collection Set-Up



Note: Not to scale.

Summary of Motorcycle Particulate Test Results

KAWASAKI KE-100

	HC (gm/km)	CO (gm/km)	Particulate (gm/km) Weighted		Cold Start		Hot Start	
Japan Test	3.7	15	---		---		---	
EPA #1 Test	5.5	20	0.320	9.8%	0.314	15%	0.325	5.7%
EPA #2 Test	5.6	21	0.353		0.365		0.344	

$$\% = \frac{\Delta}{\text{Ave.}}$$

YAMAHA DT-100

	HC (gm/km)	CO (gm/km)	Particulate (gm/km) Weighted		Cold Start		Hot Start	
Japan Test	3.8	10	---		---		---	
EPA #1 Test	3.6	10	0.068	33.1%	0.088	20.4%	0.053	47.5%
EPA #2 Test	4.0	11	0.095		0.108		0.086	

$$\% = \frac{\Delta}{\text{Ave.}}$$