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COOL OPERATION FOR HORSEPOWER PRODUCTION

Text and photography by Ricardo Topete

Mustang enthusiasts know cold air will yield more horsepower and torque than hot air. The colder the air being fed into an engine, the denser it will be, thereby allowing more oxygen to be ingested. More air equals more power. In a quest for colder air and more power, many hot-rodders have successfully used cold air kits, intercoolers, and even nitrous oxide to cool down the air charge entering the motor. A horsepower producer gaining popularity among performance buffs is carbon dioxide, also known as CO_2.

I won't bore you with the science behind CO_2, but I must point out how CO_2 can help horsepower junkies like us. In a nutshell, CO_2 has cryogenic (freezing) properties to greatly reduce temperatures. We simply approach an old concept from a new angle by cooling down an engine's air intake by using S-Max's Chill Zone CO_2 kit & Ice Tube.

S-Max has forged a strong following in the sport-compact world and began experimenting with CO_2 in an effort to further reduce inlet air temperatures on turbo/supercharged vehicles. The end result was their Chill-Zone CO_2 kit and Ice Tube.

The Chill Zone CO_2 kit is a complete system developed specifically for automotive use. The kit includes a 10-pound bottle, mounting brackets, steel braided lines, solenoid, switches, and wiring (nearly the same components included in a modern day nitrous kit). The CO_2 can be purchased at many welding supply stores, paintball supply shops, and many gas stations; making CO_2 fairly accessible. We paid $1.40/lb. for CO_2, which translates into $14 per tank. Compare that to nitrous oxide, which typically sells for around $5.00/lb. or $50 per tank.

To complement the Chill Zone CO_2 kit, S-Max also created the Ice Tube. The Ice Tube installs in the air intake tract before the throttle body and gets a charge of CO_2 pumped into it, thereby allowing the air charge to get "chilled" as it passes through the Ice Tube. Think of the Ice Tube as a tube within a tube. It measures four inches outside diameter, but three inches for the inside diameter (where the intake charge travels through). The resulting one-inch chamber created between the inside and outside tube has a coiled tube that wraps itself within those walls.

When the CO_2 is sprayed, it travels through the coiled tube inside the Ice Tube and freezes the Ice Tube from within. As the intake air charge passes through the Ice Tube, heat is removed, courtesy of the CO_2, which results in a colder, denser air charge. This process yields more power and torque.

Since the Chill Zone CO_2 kit and a nitrous kit are similar in contents and operation, the installation procedure is also similar. Anyone with nitrous experience will feel

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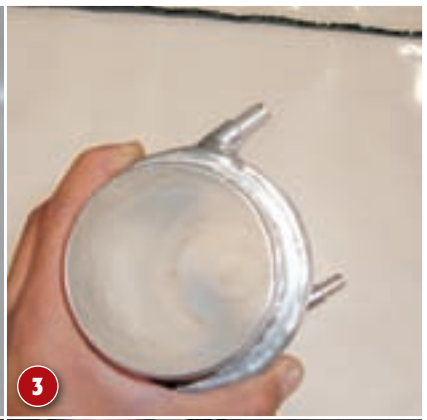
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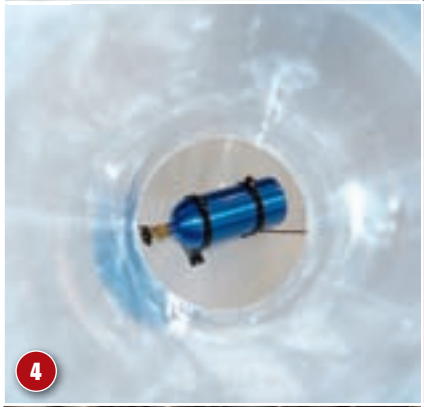
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1 Similar to a nitrous system, the Chill Zone CO_2 kit can bring added horsepower.

2 The Ice Tube provides an integral part of the cooling process

3 The view of inside of the Ice Tube reveals the "tube within a tube" concept.

4 Here's a better look at what's going on. The outside diameter is four inches while the inside diameter is only three.

5 Now is time to get down to the business at hand and it should be fairly straightforward.

6 Begin by removing the discharge tube between the supercharger and throttle body.

7 Removing the strut tower brace allowed for more room under the hood.

8 Next, trial fit the Ice Tube in place of the discharge tube and snug hose clamps.

comfortable with this system. The major difference between a nitrous kit and a CO_2 kit is that, unlike nitrous, CO_2 does not get drawn *into* the engine. The CO_2 gets discharged/vented into the atmosphere as it exits the Ice Tube. This creates an inherent safety benefit since no foreign chemicals are pumped into the engine. Instead, the engine consumes a burst of cold, dense air. Furthermore, CO_2 must be discharged away from an engine's air tract because CO_2 is inert, or non-flammable. If CO_2 were to get sucked into the air stream of a motor, it would *reduce* power output.

The Mustang gurus at GTR High Performance performed all the testing and installation. In a matter of a few hours, the CO_2 kit and Ice Tube were installed in a 2001 Mustang GT. This Mustang is no stranger to the dyno, serving as a GTR workhorse (pun definitely intended). Nicely equipped with a Paxton NOVI 1000 supercharger kit (6psi), and a few bolt-ons, we figured this car would make a good candidate and be fairly typical of what the average Mustang enthusiast owns. In

9 Measure and mark the amount needed to be trimmed from the discharge tube.

10 Carefully cut off the required amount.

addition, since this was not an intercooled supercharger kit, our theory was that it would react well to the freezing effect provided by CO_2.

By now, some of you have already jumped ahead to the dyno test results. For the few who bothered to read the article, a quick note about our testing procedures, which were done to ensure consistency and accuracy. No tuning or adjustments were done; no "doctoring" the dyno runs. The air/fuel ratio and ignition timing were locked to avoid skewing the numbers. This would allow the merits of the CO_2 to be displayed with no extra help. In other words, how much power can we gain simply by cooling down the air charge with CO_2?

To establish a baseline, we did five back-to-back runs without the CO_2 spray. The Mustang was brought to normal engine operating temperature for every run. Typical of non-intercooled supercharged cars, we noticed a fair amount of hp/torque drop after every dyno run, simply due to heat soak. A close look at the first and coldest dyno run of the day revealed the highest power output, with 282 hp @ 5,200 rpm, 312 lb-ft of torque @ 4,200 rpm, and just a tick over 6 psi boost at 5,700 rpm. Comparing the cold run to the hot, heat-soaked dyno run and the performance drop became clear. Peak numbers of 274 hp @ 5,400 rpm and 301 lb-ft of torque @ 4,200 rpm show the impact of heat. Within a few dyno pulls, the GT dropped 8 hp and 11 lb-ft of torque.

Next, we began to play with the spray. For consistency, the Mustang was brought up to the same operating temperature as all previous dyno runs. No cool-down was allowed, other than what the CO_2 delivered. We experimented a bit with how and when to spray the CO_2. In the end, we found best results by blasting the Ice Tube with CO_2 for five seconds with the engine idling, then allowing the motor to idle for a couple of minutes, and then blasting the CO_2 for another five seconds immediately before the dyno run.

Cold Dyno Run WITHOUT CO_2

RPM	HP	TORQUE	Air/ Fuel	BOOST
2600	130.93	264.49	12.00	0.00
2700	136.81	266.13	12.03	0.00
2800	141.64	265.68	12.03	0.00
2900	148.47	268.88	12.04	0.00
3000	154.82	271.04	12.07	0.00
3100	162.13	274.69	12.10	0.08
3200	170.29	279.50	12.13	0.22
3300	179.86	286.25	12.24	0.25
3400	187.69	289.92	12.25	0.11
3500	194.93	292.50	12.13	0.43
3600	202.34	295.19	12.03	0.86
3700	209.69	297.65	11.96	0.99
3800	217.02	299.95	11.93	1.09
3900	224.22	301.96	11.99	1.32
4000	231.37	303.79	12.03	1.81
4100	240.98	308.69	12.02	2.04
4200	249.62	312.15	12.02	1.90
4300	253.60	309.76	11.98	2.02
4400	259.71	310.00	11.97	2.50
4500	261.52	305.23	11.94	2.89
4600	267.69	305.64	11.88	2.87
4700	272.38	304.38	11.83	3.13
4800	272.81	298.51	11.76	3.24
4900	278.89	298.93	11.66	3.17
5000	281.93	296.16	11.68	3.86
5100	280.69	289.07	11.66	4.12
5200	282.29	285.12	11.62	4.42
5300	279.33	276.81	11.64	4.55
5400	278.91	271.27	11.72	5.13
5500	279.67	267.07	11.83	5.39
5600	276.14	258.99	11.84	5.68
5700	272.79	251.36	11.79	6.01

Hot Dyno Run WITHOUT CO_2

RPM	HP	TORQUE	Air/ Fuel	BOOST
2600	128.56	259.70	12.04	0.00
2700	134.68	261.98	12.08	0.00
2800	139.70	262.04	12.05	0.00
2900	145.55	263.60	11.99	0.00
3000	151.51	265.24	12.01	0.00
3100	158.32	268.23	12.12	0.00
3200	166.26	272.88	12.22	0.05
3300	173.77	276.55	12.29	0.29
3400	182.33	281.65	12.27	0.43
3500	190.34	285.61	12.20	0.30
3600	196.51	286.68	12.15	0.55
3700	203.87	289.39	12.11	0.87
3800	208.97	288.82	12.08	1.11
3900	217.86	293.40	12.12	1.22
4000	226.27	297.11	12.21	1.40
4100	233.15	298.66	12.22	1.66
4200	241.46	301.95	12.12	1.52
4300	244.60	298.74	12.06	1.83
4400	252.20	301.05	12.05	2.48
4500	257.14	300.11	12.04	2.53
4600	264.46	301.94	11.97	2.76
4700	265.95	297.21	11.92	2.94
4800	267.73	292.93	11.88	2.90
4900	271.36	290.95	11.78	3.12
5000	271.36	283.99	11.69	3.79
5100	270.15	279.65	11.61	3.83
5200	274.18	276.85	11.54	3.97
5300	274.63	272.18	11.57	4.36
5400	273.70	266.19	11.65	4.53

Hot Dyno Run WITH CO_2

RPM	HP	TORQUE	Air/ Fuel	BOOST
2600	135.54	273.82	13.48	0.00
2700	143.43	278.99	12.20	0.00
2800	150.04	281.43	12.04	0.00
2900	157.08	284.49	12.09	0.01
3000	162.97	285.32	12.16	0.14
3100	169.28	286.79	12.17	0.44
3200	178.11	292.32	12.19	0.56
3300	189.62	301.78	12.23	0.55
3400	198.79	307.07	12.36	0.88
3500	206.52	309.90	12.28	1.03
3600	212.55	310.09	12.17	0.92
3700	219.37	311.40	12.02	1.33
3800	229.89	317.73	11.99	1.50
3900	238.38	321.03	11.99	1.48
4000	247.77	325.32	11.98	1.81
4100	256.11	328.08	12.02	2.30
4200	262.86	28.70	12.06	2.47
4300	271.76	331.94	12.07	2.42
4400	275.43	328.77	12.07	2.70
4500	280.88	327.82	12.03	2.95
4600	287.19	327.90	11.99	2.90
4700	292.62	327.00	12.04	3.11
4800	296.06	323.95	11.91	3.60
4900	298.89	320.36	11.82	3.94
5000	301.56	316.77	11.79	4.24
5100	298.65	307.57	11.71	4.49
5200	301.96	305.00	11.57	4.73
5300	301.57	298.85	11.55	5.11
5400	302.45	294.17	11.62	5.43
5500	296.29	282.94	11.67	5.65
5600	292.88	274.68	11.62	5.69
5700	294.60	271.45	11.64	6.26

11 Install the Ice Tube and secure it to the modified discharge tube.

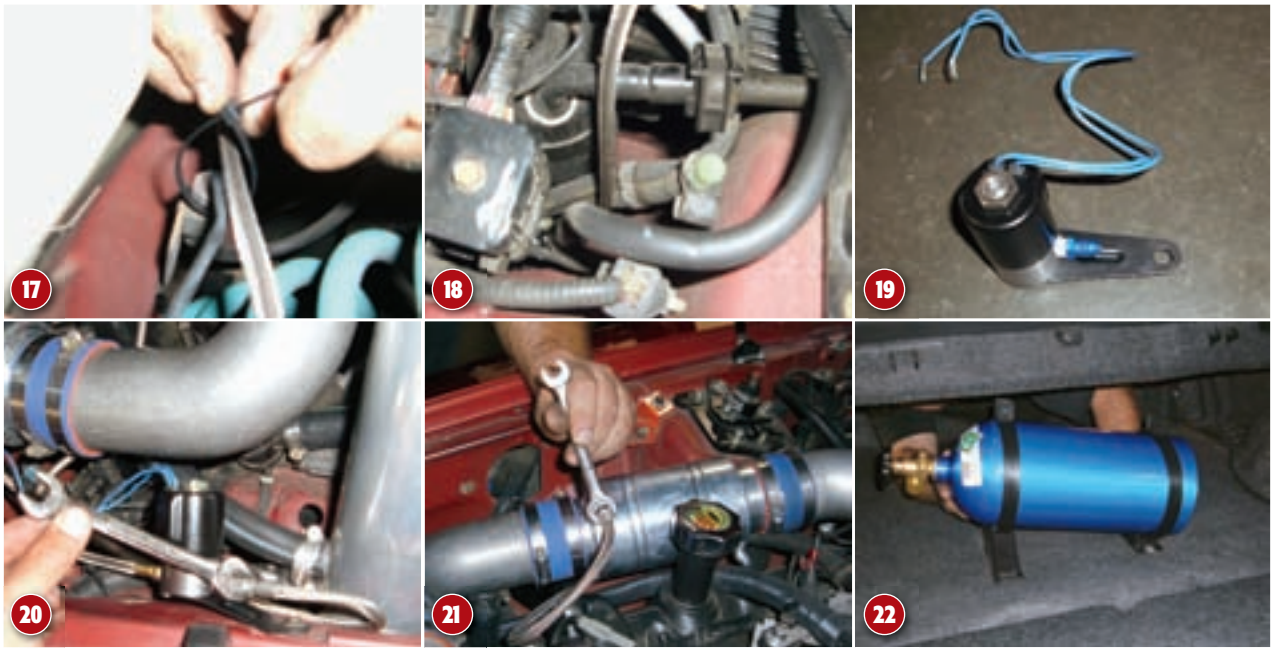
12 The ideal spot to mount the CO_2 bottle is the trunk. We chose to mount it just behind the rear seat to maximize trunk space.

13 Take note of what is under the floorboard as you are drilling.

14 Mount and secure the bottle brackets to the floorboard.

15 Conveniently, '94-'04 Mustangs have a factory hole on the passenger side of the trunk floor. That's where we ran the CO_2 line. Reuse the factory rubber grommet to insulate the CO_2 line.

16 Pull the CO_2 through the factory hole in the floor and route towards the front of the car.



17 Using zip ties, secure the CO_2 line away from moving parts.

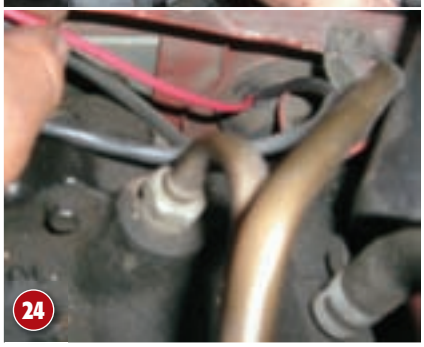
18 Feed the CO_2 line through the opening in the rear passenger corner of the engine compartment, adjacent to the stock fuel lines.

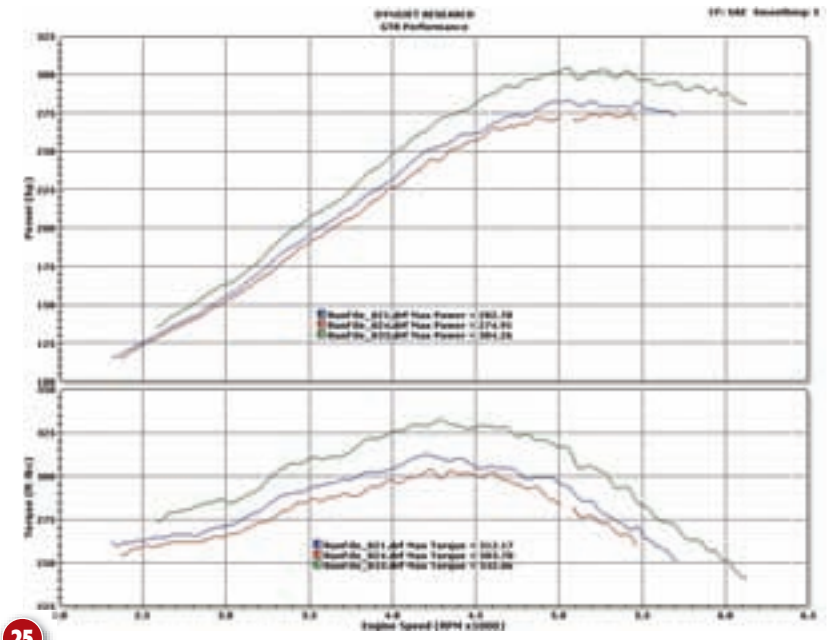
19 Here's a view of the CO_2 solenoid.

20 We mounted the CO_2 solenoid to the passenger fender in order to be near the Ice Tube.

21 Connect the CO_2 line from the solenoid to the Ice Tube.

22 Mount the CO_2 tank to the bottle brackets in the trunk and attach the CO_2 feed line.





23 For testing purposes, we routed the CO_2 purge line up and away from the engine. We will find a more permanent location at a later time.

24 We routed the wire for the solenoid through a grommet on the driver side firewall and connected it to the arming switch in the interior of the car.

25 Here's the line graph of the dyno results. Horsepower and torque gains were evident, proving this to be an economical means to gain power.

Blasting the Ice Tube twice and allowing for a couple of minutes in between blasts allows the Ice Tube to "cold-soak". In a drag-racing situation this would translate into spraying CO_2 before the burnout is done and then again just before the car is staged and ready to launch.

Studying the results of the CO_2-assisted dyno run is eye opening. Peak figures jumped to 302 hp @ 5,400 rpm, 331 lb-ft of torque @ 4,300 rpm, and 6.26 psi boost @ 5,700 rpm. A closer look between the runs with and without CO_2 paints a more impressive picture. For instance, compare the first (coldest) dyno run without the CO_2 to the dyno-run with the CO_2 spray. Peak gains checked in at 23.54 hp and 25.44 lb-ft of torque. Further examination reveals that over 10 hp is available from 3,300 rpm on and more than 10 more lb-ft torque is on tap from an early 2,700 rpm until the end of the run. As notable as these results are, even more impressive is the comparison of the hot dyno run without CO_2 to the dyno run with the CO_2. Peak gains jumped to 30.2 hp and 33.2 lb-ft of torque! There were increases of over 10 hp from 2,800 rpm and over 20 hp from 3,800 rpm until the end of the run. Torque is improved by more than 14 lb-ft the moment the loud pedal is buried.

Clearly, the CO_2 delivers large doses of power throughout the entire rpm range, not just at the top of the tach. On a road test, this translated into an extra shot of oats to the Mustang the moment the hammer was dropped. The newfound power delivered a satisfying sensation, allowing the Mustang to pull harder, quicker and longer before power dropped off. Essentially, the Chill Zone CO_2 and Ice Tube kit provide a poor-man's intercooler by allowing substantially lower air temps to produce more power and torque.

The Chill Zone and Ice Tube can also be used in a naturally-aspirated vehicle. We would wager the results would be less than that of a supercharged/turbocharged vehicle. It would also be interesting to see the effects of CO_2 on a higher output supercharger kit, say 10-12 psi, or better yet, one already equipped with an intercooler. Based on our findings, we would speculate that a higher output blower kit would show larger power gains as they generate higher inlet air temperatures and, as a result, would react favorably to the freezing effect.

Space would be the only limiting factor for this system. You need sufficient room to mount the Ice Tube before the throttle body. With an overall length of 9¾ inches, the Ice Tube may pose a fitment issue on some crowded engine compartments. In our GT, it fit beautifully…kudos to the staff at GTR for a job well done.

As is the case in the automotive performance world, speed costs money. However, you will be glad to know that the price of admission for the Chill Zone and Ice Tube kits is reasonable. GTR sells the Chill Zone kit for just under $400 and the Ice Tube comes in at about $250. Factor in less than $15 for a 10 lb. fill up and you are ready for action. ■

SOURCES

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