Guideline For Setting Open Rails Braking Parameters (Including Blended Braking)

A while back I noticed most of my trains weren't braking as they did under MSTS. Since I no longer use MSTS, I decided to try to optimize braking parameters for Open Rails. At the same time I also discovered that a lot of new features had been added. Among the most exciting was the ability to customize brake shoe friction with speed. This would finally let me adjust braking rates to match real world values, or at least get very close.

The first order of business was to do some research into how air brakes function in the real world, including how fast they apply and release, as well as typical braking rates. I found much documentation which I listed below:

Dual Disc/Tread Braking Tests (Amfleet coaches):

https://www.fra.dot.gov/Elib/Document/15054

Air Brake Principles and Specific Equipment:

https://www.wplives.org/forms_and_documents/Air_Brake_Principles.pdf

Testing For Current Freight Car Braking Ratios on the Union Pacific Railroad:

http://www.standardsteel.com/rdpapers/freightcar.pdf

The 26-L Brake Equipment:

https://www.nyab.com/media/nyab_1/documents_1/technical/instructionpamphletsip/ip_074.pdf

Railway Air Brake Model and Parallel Computing Scheme:

https://computationalnonlinear.asmedigitalcollection.asme.org/article.aspx?articleid=2618478

A Simple and Efficient Train Braking Algorithm for PTC Systems:

https://www.arema.org/files/library/2011_Conference_Proceedings/Simple_and_Efficient_Train_Braking_Algorithm_for_PTC_Systems.pdf

The last two links are for computer modeling of brake systems. These might come in handy to the Open Rails programming team.

When setting brake parameters the first things you need are the braking ratios, the brake cylinder pressure for those braking ratios (typically either 50 psi or 64 psi), type of brake shoes, and maximum emergency brake pressure. It's typical practice to specify brake shoe force as some percentage of car weight. This is what you use to determine the value of the **MaxBrakeForce** parameter. Note that in Open Rails the **MaxBrakeForce** parameter is the actual maximum brake force at the wheel rim. Therefore, you have to take into account the coefficient of friction of the brake shoes. In order to do that you have to know what type of brake shoes are in use. For this example let's assume we're using composite brake shoes. This gives us the following for the **ORTSBrakeShoeFriction** parameter:

```
ORTSBrakeShoeFriction ( 0.0 0.49 8.0 0.436 16.1 0.4 24.1 0.371 32.2 0.35 40.2 0.336
48.3 0.325 56.3 0.318 64.4 0.309 72.2 0.304 80.5 0.298 88.5 0.295 96.6 0.289 104.6
0.288)
```

Or you can use this for cast iron shoes:

```
ORTSBrakeShoeFriction ( 0.0 0.50 8.0 0.288 16.1 0.241 24.1 0.211 32.2 0.187 40.2 0.173
48.3 0.161 56.3 0.150 64.4 0.142 72.2 0.139 80.5 0.134 88.5 0.129 96.6 0.125 104.6
0.123 112.7 0.121)
```

Note that the coefficient of friction for composite shoes at zero speed is 0.49. Open Rails normalizes the braking curve to the maximum coefficient of friction value. Therefore, you set **MaxBrakeForce** to whatever the actual maximum braking force at the wheel rim is, not to the maximum brake shoe force. However, you need to use the maximum brake shoe force in your calculations. Let's say that the braking ratio is 38% of the car weight, and also that this is specified at 64 psi brake cylinder pressure. Let's also say that the car weighs 35 metric tons. This gives us a **MaxBrakeForce** of 0.38*35t*0.49 = 6.517t or 6.517*9.80665 = 63.9 kN.

However, we're not done yet. **BrakeCylinderPressureForMaxBrakeBrakeForce** is a very important parameter. I've noted that Open Rails never lets the brake cylinder pressure go higher than the value set in **BrakeCylinderPressureForMaxBrakeBrakeForce**, regardless of the brake pipe pressure. For example, you could do a 26 pound reduction in a 90 psi brake pipe, which in theory should give you 64 psi brake cylinder pressure. If you set **BrakeCylinderPressureForMaxBrakeBrakeForce** to 50, the brake cylinder pressure will never go higher than 50. Therefore, **BrakeCylinderPressureForMaxBrakeBrakeForce** must be set to the maximum brake cylinder pressure, which typically occurs under emergency braking. This is usually 20% more than full service pressure, or about 77 psi for 90 psi freight systems, and about 93 psi for 110 psi passenger systems. Since this example is a freight car, we'll use **BrakeCylinderPressureForMaxBrakeBrakeForce** (77). When you do this, you need to adjust the **MaxBrakeForce** value proportionally so you will still get 63.9 kN at 64 psi. The final parameters then are:

```
MaxBrakeForce( 76.9kN )
BrakeCylinderPressureForMaxBrakeBrakeForce( 77 )
```

Now you want to start adjusting other parameters:

```
EmergencyBrakeResMaxPressure( 110 )
EmergencyResVolumeMultiplier ( 1.461 )
TripleValveRatio( 2.5 )
MaxReleaseRate( 6 )
MaxApplicationRate( 6 )
MaxAuxilaryChargingRate( 20 )
EmergencyResCapacity( 0.839ft^3 )
EmergencyResChargingRate( 20 )
BrakePipeVolume( 0.46ft^3 )
```

Some of these are self-explanatory. Others need explanation. I determined the value of **EmergencyResCapacity** from real world values given in *Railway Air Brake Model and Parallel Computing Scheme,* which I linked to earlier. They gave the auxiliary reservoir volume as 40 liters, but this is typically divided into two parts, namely the emergency reservoir and auxiliary reservoir. Open Rails has no parameter for auxiliary reservoir volume, but the **EmergencyResVolumeMultiplier** gives the ratio of the emergency reservoir volume divided by the auxiliary reservoir volume. Therefore, the emergency reservoir volume is equal to the auxiliary reservoir volume times 1.461, and together both have a

volume of 40 liters. This means the auxiliary reservoir volume is 40 divided by 2.461 = 16.253 liters, and the emergency reservoir volume is 40 – 16.253 = 23.747 liters = 0.839 cubic feet.

BrakePipeVolume can be calculated by multiplying the car length in feet by 0.0089. **MaxApplicationRate** should reflect the maximum rate the brake cylinder pressure changes in psi/sec under emergency braking. **MaxReleaseRate** should reflect the maximum rate the brakes can release. Based on the graphs in *Railway Air Brake Model and Parallel Computing Scheme* I used 6 psi/sec for both. I'm not sure what to use for **EmergencyResChargingRate** and **MaxAuxiliaryChargingRate** but 20 for both seems to be fairly commonly used in most .eng and .wag files. The complete brake section for this wagon therefore would be as follows:

```
BrakeEquipmentType("Handbrake, Triple_valve, Auxilary_reservoir,
Emergency_brake_reservoir" )

BrakeSystemType( "Air_single_pipe" )

MaxHandbrakeForce( 35kN )
NumberOfHandbrakeLeverSteps( 100 )
EmergencyBrakeResMaxPressure( 110 )
EmergencyResVolumeMultiplier ( 1.461 )
TripleValveRatio( 2.5 )
MaxReleaseRate( 6 )
MaxApplicationRate( 6 )
MaxAuxilaryChargingRate( 20 )
EmergencyResCapacity( 0.839ft^3 )
EmergencyResChargingRate( 20 )
MaxBrakeForce( 76.9kN )
BrakeCylinderPressureForMaxBrakeBrakeForce( 77 )
ORTSBrakeShoeFriction ( 0.0 0.49 8.0 0.436 16.1 0.4 24.1 0.371 32.2 0.35 40.2 0.336
48.3 0.325 56.3 0.318 64.4 0.309 72.2 0.304 80.5 0.298 88.5 0.295 96.6 0.289 104.6
0.288)
BrakePipeVolume( 0.46ft^3 )
```

The same methodology is used to set the brake parameters in the wagon section of .eng files. However, there are a lot of additional brake parameters in the engine section of .eng files which need to be set. Here are the brake parameters used in the engine section of the SD90MAC (other North American freight locomotives should be very similar):

```
BrakesEngineBrakeType( "Air_single_pipe"  )
BrakesTrainBrakeType( "Air_single_pipe" )
BrakesEngineControllers( "Independent, Train, Dynamic" )

AirBrakesAirCompressorPowerRating( 1.1 )
AirBrakesMainMinResAirPressure( 0 )
AirBrakesMainMaxAirPressure( 130 )
AirBrakesMainResVolume( 33.8ft^3 )
AirBrakesAirCompressorWattage( 19000 )
AirBrakesCompressorRestartPressure( 120 )
AirBrakesAirUsedPerPoundsOfBrakePipePressure( 2 )
AirBrakesHasLowPressureTest( 1 )
AirBrakesIsCompressorElectricOrMechanical( 1 )

ORTSMainResChargingRate ( 0.326 )
ORTSBrakePipeChargingRate ( 200 )
ORTSEngineBrakeReleaseRate ( 38 )
ORTSEngineBrakeApplicationRate ( 34 )
```

```
ORTSBrakePipeTimeFactor ( 0.005 )
ORTSBrakeEmergencyTimeFactor ( 0.1 )
ORTSBrakeServiceTimeFactor ( 0.25 )
TrainPipeLeakRate ( 0.0833 )
TrainBrakesControllerMaxApplicationRate( 1.3 )
TrainBrakesControllerMaxReleaseRate( 1.7 )
TrainBrakesControllerMaxQuickReleaseRate( 20.0 )
TrainBrakesControllerEmergencyApplicationRate( 50 )
EngineBrakesControllerMinPressureReduction( 6 )
TrainBrakesControllerMinPressureReduction( 6 )
EngineBrakesControllerFullServicePressureDrop( 26 )
TrainBrakesControllerFullServicePressureDrop( 26 )
EngineBrakesControllerMaxSystemPressure( 90 )
TrainBrakesControllerMaxSystemPressure( 90 )
```

Note that many of the parameters for the compressor in the first section aren't used by open Rails. They're just there for MSTS compatibility. The ones which really seem to be necessary for Open Rails are **AirBrakesMainResVolume**, **AirBrakesCompressorRestartPressure**, **AirBrakesMainMaxAirPressure**, and **AirBrakesIsCompressorElectricalOrMechanical**.

Now let's explain some of these values. **TrainbrakesControllerMaxReleaseRate** and **TrainbrakesControllerMaxApplicationRate** determine the rate maximum rate of change in brake pipe pressure in psi/sec when releasing and applying the brakes in service mode, respectively. **TrainbrakesControllerMaxQuickReleaseRate** is there in case Open Rails incorporates quick release in the future but it's not used for the time being. **TrainbrakesControllerEmergencyApplicationRate** controls how rapidly the brake pipe pressure drops in emergency but I suspect Open Rails may not need this parameter because it already uses **ORTSBrakeEmergencyTimeFactor** for the same purpose. As already mentioned earlier, no matter how rapidly the brake pipe pressure drops, the brakes will apply no faster than specified by the **MaxApplicationRate** in the wagon files.

EngineBrakesControllerMinPressureReduction and **TrainBrakesControllerMinPressureReduction** both specify the minimum brake pipe reduction, and 6 psi is typical. A very useful parameter is **TrainBrakesControllerFullServicePressureDrop**, which allows you to specify a lower full service pressure drop than the usual 2/7ths of the brake system pressure. It's more useful for passenger equipment than for freight equipment. For example, the Amfleet coaches use a 110 psi brake system, which normally means a maximum brake pipe reduction of 31.4 psi. However, Amtrak typically uses a 68 psi brake cylinder pressure for full service braking, which means maximum brake pipe reduction in service mode is only 27 psi, not 31.4 psi. **EngineBrakesControllerFullServicePressureDrop** can perform a similar function for the independent brakes.

ORTSEngineBrakeReleaseRate and **ORTSEngineBrakeApplicationRate** are used to specify how fast the locomotive's independent brake can release and apply. **ORTSMainResChargingRate** specifies how rapidly the main reservoir recharges in psi/sec. Note that this number only applies when the brake pipe, auxiliary, and emergency reservoirs are at their maximum pressure, which is 90 psi in this case, and the compressor is only recharging the main reservoir. If they are at a lower pressure, the compressor must recharge them, and the recharge rate is reduced proportionally by the ratio of the main reservoir volume divided by the combined volume of the main reservoir, brake pipe, and auxiliary reservoirs. **ORTSBrakePipeTimeFactor** determines the propagation rate of the brake signal down the brake pipe, which is typically about 600 feet per second. The default value of 0.003 was a little too fast. 0.005 or 0.006 works better. I'm still not sure of the best value for **ORTSBrakeserviceTimeFactor**. Changing it doesn't seem to have much effect one way or another.

ORTSBrakePipeChargingRate merits further explanation. The default value of 21 psi/sec seems very low, as I noted by how long it took the brakes to release on a relatively short passenger train. The reason for this is that Open Rails reduces the brake pipe charging rate by the ratio of the locomotive brake pipe volume to the total train brake pipe volume, which might have 10 times the volume or more, even for a passenger train. As a result, the brake pipe might only charge at 1 or 2 psi/sec, which means it would take 10 or 20 seconds or more to release a full service application. In general it's a good idea to set **ORTSBrakePipeChargingRate** high enough so that it doesn't limit the brake pipe release rate specified by **TrainbrakesControllerMaxReleaseRate**. I found 200 or so seems to work well for both passenger and freight trains.

The methodology is similar for passenger trains. Here is the brake section for my Amfleet coaches:

```
BrakeEquipmentType( "Distributor, Auxiliary_reservoir, Emergency_brake_reservoir" )

BrakeSystemType( "Air_twin_pipe" )
comment (standard COBRA brake curve adjusted for size of brake disk and known Amfleet
braking curve)
ORTSBrakeShoeFriction ( 0.0 0.49 16.1 0.436 32.2 0.4 48.3 0.371 64.4 0.35 80.5 0.336
96.6 0.318 128.7 0.295 144.8 0.289 156.9 0.288)
MaxBrakeForce ( 102kN )

EmergencyBrakeResMaxPressure( 140 )
TripleValveRatio( 2.5 )
EmergencyResVolumeMultiplier ( 1.461 )
EmergencyResCapacity( 1.5 )
EmergencyBrakeTriggerRate( 16 )
MaxReleaseRate( 30 )
MaxApplicationRate( 30 )
MaxAuxilaryChargingRate( 15 )
EmergencyResChargingRate( 20 )
BrakeCylinderPressureForMaxBrakeBrakeForce( 93 )
BrakePipeVolume ( 0.76ft^3 )

BrakeDistributorFullServicePressure( 78 )
BrakeDistributorEmergencyApplicationPressure( 93 )
BrakeDistributorMaxAuxilaryResPressure( 110 )
BrakeDistributorEmergencyResPressure( 110 )
BrakeDistributorReleaseRate( 30 )
BrakeDistributorApplicationRate( 30 )
BrakeDistributorTrainPipeControlRatio( 2.5 )
BrakeDistributorNormalFullReleasePressure( 110 )
```

Note there are parameters for the brake distributor for MSTS compatibility, although I don't think they're necessary for Open Rails. Not sure of the Emergency Reservoir size here. I suppose I could use the value of 0.839 cubic feet which I used for freight cars. Operationally, it probably wouldn't make much difference. One thing of note is the **ORTSBrakeShoeFriction** parameter. I tried to match the tested braking rates given in the Dual Disc/Tread Braking Tests study performed on the Amfleet coaches. To get a good match, I needed to adjust the braking curve. The rationale here was the swept area of the disc brake was probably about half the wheel diameter. Therefore, the friction coefficients at various points would apply at roughly twice the speed they would with a tread brake. Also note that **BrakeCylinderPressureForMaxBrakeBrakeForce** is 93, which is the brake cylinder pressure for emergency braking.

Here are the parameters in the wagon section of the AEM-7 locomotive:

```
BrakeEquipmentType( "Distributor, Auxilary_reservoir, Emergency_brake_reservoir" )

BrakeSystemType( "Air_twin_pipe" )

comment ( 70% COBRA brake, 30% cast iron brake )
ORTSBrakeShoeFriction ( 0.0 0.49 12.1 0.354 24.1 0.343 36.2 0.314 48.3 0.293 60.4
0.279 72.4 0.269 84.5 0.262 96.6 0.254 108.6 0.249 120.7 0.245 132.8 0.243 144.8 0.239
156.9 0.238)

MaxBrakeForce ( 206.842kN )
EmergencyBrakeResMaxPressure( 110 )
TripleValveRatio( 2.5 )
MaxReleaseRate( 30 )
MaxApplicationRate( 30 )
MaxAuxilaryChargingRate( 15 )
EmergencyResCapacity( 4.15 )
EmergencyResChargingRate( 20 )
EmergencyResVolumeMultiplier ( 0.325 )
BrakeCylinderPressureForMaxBrakeBrakeForce( 93 )
BrakePipeVolume ( 0.48ft^3 )

BrakeDistributorFullServicePressure( 78 )
BrakeDistributorEmergencyApplicationPressure( 93 )
BrakeDistributorMaxAuxilaryResPressure( 110 )
BrakeDistributorEmergencyResPressure( 110 )
BrakeDistributorReleaseRate( 30 )
BrakeDistributorApplicationRate( 60 )
BrakeDistributorTrainPipeControlRatio( 2.5 )
BrakeDistributorNormalFullReleasePressure( 110 )
```

Again, it's worth noting the **ORTSBrakeShoeFriction** parameter. The AEM-7 uses composite disk brakes and cast iron tread brakes in a roughly 70/30 ratio. I tried to match the braking curve to that. In practice I'm not sure if it makes much real difference given that most of the braking comes from the coaches.

Here are the parameters in the engine section of the AEM-7 .eng file:

```
BrakesEngineBrakeType( "Air_twin_pipe" )
BrakesTrainBrakeType( "Air_twin_pipe" )

BrakesEngineControllers( "Independent, Train, Dynamic, Blended" )

AirBrakesAirCompressorPowerRating( 3.93 )
AirBrakesMainMinResAirPressure( 30 )
AirBrakesMainMaxAirPressure( 140 )
AirBrakesMainResVolume( 35ft^3 )
AirBrakesAirCompressorWattage( 19000 )
AirBrakesCompressorRestartPressure( 132 )
AirBrakesAirUsedPerPoundsOfBrakePipePressure( 1.4 )
AirBrakesHasLowPressureTest( 0 )
AirBrakesIsCompressorElectricOrMechanical( 0 )

EngineBrakesControllerDirectControlExponent( 1 )
TrainBrakesControllerDirectControlExponent( 1 )
EngineBrakesControllerMinPressureReduction( 6 )
TrainBrakesControllerMinPressureReduction( 6 )
EngineBrakesControllerHasProportionalBrake( 1 )
EngineBrakesProportionalBrakeLag( -0.6 )
EngineBrakesControllerMaxApplicationRate( 30 )
```

```
TrainBrakesControllerMaxApplicationRate( 30 )
EngineBrakesControllerMaxReleaseRate( 30 )
TrainBrakesControllerMaxReleaseRate( 30 )
EngineBrakesControllerEmergencyApplicationRate( 40 )
TrainBrakesControllerEmergencyApplicationRate( 40 )
EngineBrakesControllerMinSystemPressure( 30 )
TrainBrakesControllerMinSystemPressure( 30 )
EngineBrakesControllerMaxSystemPressure( 110 )
TrainBrakesControllerMaxSystemPressure( 110 )
EngineBrakesControllerEmergencyBrakeTimePenalty( 60 )
EngineBrakesControllerFullServicePressureDrop( 27 )
TrainBrakesControllerEmergencyBrakeTimePenalty( 60 )
TrainBrakesControllerFullServicePressureDrop( 27 )

ORTSBrakePipeChargingRate ( 200 )
ORTSBrakePipeTimeFactor ( 0.005 )
ORTSMainResChargingRate ( 0.575 )
TrainPipeLeakRate ( 0.0833 )
ORTSEngineBrakeReleaseRate ( 38 )
ORTSEngineBrakeApplicationRate ( 34 )
ORTSBrakeEmergencyTimeFactor ( 0.1 )
ORTSBrakeServiceTimeFactor ( 1.009 )
```

As mentioned earlier, I use **TrainBrakesControllerFullServicePressureDrop(27)** to get a full service brake cylinder pressure of 68 psi. The brake parameters in bold are just there for MSTS compatibility, and not used by Open Rails.

The AEM-7 also incorporates blended braking. In order to allow more control over how this works, it's better to specify the dynamic brake parameters via the **ORTSDynamicBrakeForceCurves** parameter instead of using the MSTS dynamic brake parameters:

```
ORTSDynamicBrakeForceCurves (
 0.10 (
     0.00       0
     6.04       0
     6.24   15124
    28.84   15124
    33.31   13094
    37.78   11545
    42.26   10324
    46.73    9336
    51.20    8521
    55.67    7837
    60.14    7254
    64.61    6752
 )
 0.20 (
     0.00       0
     6.04       0
     6.44   30248
    28.84   30248
    33.31   26189
    37.78   23090
    42.26   20648
    46.73   18672
    51.20   17042
    55.67   15673
    60.14   14508
    64.61   13504
  )
```

```
0.30 (
    0.00      0
    6.04      0
    6.64  45372
   28.84  45372
   33.31  39283
   37.78  34636
   42.26  30971
   46.73  28008
   51.20  25563
   55.67  23510
   60.14  21762
   64.61  20256
)
0.40 (
    0.00      0
    6.04      0
    6.84  60496
   28.84  60496
   33.31  52378
   37.78  46181
   42.26  41295
   46.73  37344
   51.20  34084
   55.67  31346
   60.14  29016
   64.61  27008
)
0.50 (
    0.00      0
    6.04      0
    7.04  75620
   28.84  75620
   33.31  65472
   37.78  57726
   42.26  51619
   46.73  46680
   51.20  42604
   55.67  39183
   60.14  36270
   64.61  33761
)
0.60 (
    0.00      0
    6.04      0
    7.24  90744
   28.84  90744
   33.31  78567
   37.78  69271
   42.26  61943
   46.73  56017
   51.20  51125
   55.67  47020
   60.14  43524
   64.61  40513
)
0.70 (
    0.00      0
    6.04      0
    7.44 105868
   28.84 105868
   33.31  91661
   37.78  80817
```

```
         42.26  72267
         46.73  65353
         51.20  59646
         55.67  54856
         60.14  50778
         64.61  47265
      )
      0.80 (
          0.00       0
          6.04       0
          7.64 120992
         28.84 120992
         33.31 104756
         37.78  92362
         42.26  82591
         46.73  74689
         51.20  68167
         55.67  62693
         60.14  58032
         64.61  54017
      )
      0.90 (
          0.00       0
          6.04       0
          7.85 136116
         28.84 136116
         33.31 117850
         37.78 103907
         42.26  92914
         46.73  84025
         51.20  76688
         55.67  70529
         60.14  65286
         64.61  60769
      )
      1.00 (
          0.00       0
          6.04       0
          8.05 151239
         28.84 151239
         33.31 130945
         37.78 115452
         42.26 103238
         46.73  93361
         51.20  85209
         55.67  78366
         60.14  72540
         64.61  67521
      )
   )
```

You'll still need to specify some of the MSTS dynamic brake parameters but not all of them:

```
comment ( air brakes bail off when dynamic brake force > 0.6*130kN = 17536lb )
DynamicBrakesMaximumForce( 130kN )
DynamicBrakesCutInSpeed( 15 )
DynamicBrakesMaxAirBrakePressure ( 80 )
DynamicBrakesDelayTimeBeforeEngaging ( 1 )
DynamicBrakesNumberOfControllerNotches( 0 )
DynamicBrakeHasAutoBailOff( 1 )
ORTSDynamicBrakeBlendingForceMatch ( 1 )
```

If set to 1 the Open Rails parameter **ORTSDynamicBrakeBlendingForceMatch** attempts to match the dynamic brake force to the force the friction brake would have at the same brake cylinder pressure, subject of course to the limitations of the locomotive's dynamic braking capability. **DynamicBrakeHasAutoBailoff (1)** will bail off the locomotive's independent brakes when the dynamic braking force is over 0.6***DynamicBrakesMaximumForce**. Due to the fact the locomotive's dynamic braking curve was specified via the **ORTSDynamicBrakeForceCurves** parameter, the **DynamicBrakesMaximumForce** parameter does not need to have any bearing on reality. You simply specify it to get the locomotive's independent brakes to bail off when you want them to. In this case, I wanted the independent brakes to stay off until the dynamic brakes started fading. Note that the dynamic brakes are weakest at their highest operational speed. The highest operational speed of the AEM-7 locomotive is 125 mph, and the dynamic braking force at that speed, based on the maximum braking power of 5850 HP, is 17550 pounds, or 78.06 kN. The independent brakes are supposed to bail off when the dynamic braking force is equal to or greater than 78.06 kN. Open Rails uses 60% of the **DynamicBrakesMaximumForce** parameter as the bailoff point. Therefore, **DynamicBrakesMaximumForce** must be 78.06/0.6, or 130.1 kN (130 kN is close enough). These values work nicely. When the train is braked, the dynamic brake comes on at the lesser of either the same value the friction brake would have had, or the maximum dynamic braking force at that speed. The dynamic brake starts fading below 18 mph. Once the braking force drops under 78.06 kN, the independent brakes come in.

Because Open Rails attempts to match the dynamic brake force to the friction brake force, it's also necessary to specify the friction brake parameters so the braking force is equal or greater than the maximum dynamic brake force under full service braking. Full service braking in this case occurs at a brake cylinder pressure of 68 psi. With **BrakeDistributorEmergencyApplicationPressure(93)** and **MaxBrakeForce (206.842kN)** the full service brake force is 151.2 kN, which is the same as the AEM-7's maximum dynamic brake force. If you use a lower value for **MaxBrakeForce**, then the dynamic brake force will be limited to less than its maximum value under full service braking, perhaps even under emergency braking if **MaxBrakeForce** is very low.

If you don't want the independent brakes to bail off when the dynamic brakes are on, then just use **DynamicBrakeHasAutoBailoff (0)**.

Tweaking blended braking in a similar manner will also be very useful for EMUs, which often use solely dynamic braking until they're only going a few mph.