Built at GWR's Swindon Works in June 1930, for most of its working life it was allocated to Plymouth Laira shed. Transferred to Old Oak Common, London, in March 1959, and finally to Cardiff Canton in 1962.

6024 was fitted new cylinders and in November 1957, with its chimney and blast-pipe modifications. In March 1960, it was fitted with its final boiler (boiler no. 8610, previously fitted new to No. 6027 in 1953, and overhauled for No. 6018, No. 6000, and No. 6024). In just over two years up to withdrawal, the locomotive ran 94,384 miles with this boiler.

King Edward I ran for over thirty years on the Great Western Railway and the Western Region of British Railways, regularly hauling prestige express passenger services such as the "Cornish Riviera Express", "The Bristolian", "The Inter City" and the "Cambrian Coast Express". It worked a total of 1,570,015 miles and was a member of the elite group of Kings which recorded speeds of 100 mph or more on a number of occasions.

Sent to Swindon for breaking up, it had one final unusual task – coupled to its twin, 6023 King Edward II, it was towed over a bridge for weight testing purposes. After the weight testing they were to be scrapped at Briton Ferry at Neath until it was realised that the King class locomotives were not allowed west of Cardiff. They were then sent to Woodham Brothers scrapyard at Barry as this involved less travelling than taking the engines back to Swindon.

Inspired by preserved class-mate 6000 King GeorgeV's 1971 breach of British Rail's steam ban, in 1973 the King Preservation Society wanted to restore a locomotive to mainline condition. Both Nos. 6023 and 6024 were available for purchase, but No. 6024 was preferred, because after a derailment in the Barry yard No. 6023 had had its rear driving wheels torched through, and at the time was considered beyond repair.

6024 was bought for £4,000 in 1974 by the 6024 King Preservation Society, but like many other remaining locomotives, was missing significant components, including: its double-chimney (currently fitted to 6000), piston, connecting and eccentric rods, and its slide-bars had been cut through.

The 36th locomotive to be rescued from Barry, 6024 was moved to the Buckinghamshire Railway Centre at Quainton Road. After 16 years, including the creation of the Club100 funding initiative, on 2 February 1989, 6024 moved again under its own power. Re-commissioned on 26 April 1989 by HRH the Duke of Gloucester, in October 1989 the engine was moved by low-loader from Quainton Road to the Birmingham Railway Museum at Tyseley, from where it completed its mainline test runs. On 15 April 1990, it resumed its mainline career hauling revenue-earning passenger trains.

In recognition of the high standard to which the locomotive had been restored, 6024 was outright winner of the 1990 British Coal sponsored Heritage Award (for a restoration project using coal), and awarded a £3,000 prize which was put towards the restoration of a British Railways Mark 1 BSK coach, for transporting support crew and equipment for mainline work.

The Society was invited by British Rail to provide No. 6024 to haul the a Inter City VIP special on 19 May 1990. In July 1990 it appeared at the National Railway Museum Exhibition On Tour which was held at Swindon Works, where it celebrated its 60th anniversary and was stabled alongside classmate No. 6000 King George V.

The locomotive was used for an expanding mainline tour programme, based at either Tyseley, Didcot or Hereford Railway Centre. In late 1991 the locomotive was invited to haul the "William Shakespeare Express" from London Paddington, its first appearance there for almost thirty years.

As open access to the national network brought more routes into play in early 1992, 6024 was increasingly seen hauling passenger charter trains on a number of previously banned routes, including the mainlines to the West of England via Bristol, and South Wales through the Severn Tunnel. Fitted with BR's standard Automatic Warning System (permitting speeds up to 75 mph), 6024 reintroduced steam-hauled express passenger trains to a number of new destinations within western zones for the first time for many years.

In August 1992 the locomotive made its promised return to Quainton Road, this time via the mainline, when in the company of GWR 4073 class 5029 Nunney Castle it hauled shuttles to and from Aylesbury.

However, plans to take a train to Plymouth were thwarted by the locomotive's cab height preventing it from passing an over-bridge at Plympton.

After running almost 10,000 mainline miles, in March 1995 the locomotive withdrew from traffic for its heavy overhaul at the end of its mainline boiler certificate, and it retired to a secure Ministry of Defence site at Kineton in Warwickshire for the Society to carry out the work. In September 1996 it reappeared with a number of small but significant modifications, incorporated in order to make it more adaptable and to increase its availability.

The modifications included the fitting of dual-braking equipment (air and vacuum) to increase flexibility in the use of passenger rolling stock, and the reduction of its chimney, safety valves and cab-roof heights to permit it to fit within the standard loading guage. This allowed it to make its return to Plymouth, first double-headed in November 1996, and then in April 1997 running solo. This was the first time an unassisted steam locomotive had been entrusted with a passenger train over the route since the early 1960s. In August 2002 6024 broke the record for steam haulage with the fastest modern-day time for the 52 miles from Plymouth to Exeter, in 58 minutes 6 seconds.

With a further 15,000 mainline miles on the clock, in October 2002 the locomotive was again withdrawn for its second major overhaul, which was being carried out by the Society within the site of Tyseley Locomotive Works. To keep pace with safety improvements, the locomotive was fitted with standard Train Protection & Warning System (TPWS), and the Society also completed its water wagon project for mainline trials. This will enable mainline water-stops to be avoided on certain routes. 6024 returned to the mainline on 7 October 2004, on its third 7-year main line certificate.

On 10 June 2008, 6024 hauled the Royal Train, with Charles, Prince of Wales and the Duchess of Cornwall on board, from Kidderminster Town to Bridgnorth on the Severn Valley Railway. Between Bewdley and Arley, The Prince of Wales drove the locomotive under the guidance of Bob Lane.

Before leaving the SVR to resume its mainline appointments a broken tender axlebox was discovered that delayed its departure. Once repaired, a further delay was incurred by a defect in the air pump.

In 2011 the locomotive was sold to the Royal Scot Locomotive & General Trust, amid legal disputes.

Following an internal dispute within the 6024 Society which had owned the locomotive since its preservation, an unsuccessful legal case was pursued in 2010, which resulted in a loss in the High Court. The resulting requirement to pay compensation and both parties' legal costs totalling over £500,000, resulted in the society becoming deficient in liquid cash funds.

Following discussions with various interested parties, in December 2010 the society agreed to sell the locomotive to the Royal Scot Locomotive and General Trust (RSL&GT), chaired by investor and steam enthusiast Jeremy Hosking.

Work began in April 2012 at the West Somerset Railway workshops on a 10 yearly heavy overhaul. The boiler was sent for overhaul to Ian Riley at Heywood where work on the wheelsets has also been undertaken.

The driving wheels were subsequently sent to the South Devon Railway at Buckfastleigh for re-tyring and turning at Tyseley.

By early 2017 work had progressed to the stage where new cylinders could be fitted at the West Somerset Railway. The casting for these cylinders are of reduced width to increase the locomotive's man line route availability. The boiler remains under overhaul at Riley & Son € Ltd.

In March 2018 the frames were fitted onto the wheels again at Minehead.

In November 2019 the boiler passed its hydraulic and steam tests.

The overhauled boiler was returned to Minehead from Riley & Son E Ltd in January 2020 and craned back onto the frames.

As part of the overhaul the locomotive is being fitted with components for main line operation. This includes two new whistles which are lower than the previous ones, narrower cylinders and a slight reduction in the height of the safety valves.

The reported cost of the overhaul for work done up to end of March 2020 was £1.7m.

It had been hoped that the overhaul of the locomotive would be largely completed by June 2020 but as a result of the Covid-19 this could not be achieved.

The tender was rebuilt by volunteers of the 6024 Preservation society, with assistance from Bennett Boilers. When this was done it was discovered that the tender dates from 1929 which is the year before the locomotive was completed.

The goal was to have the locomotive available in April 2021 but this proved not to be possible. In July 2022 the hope was that the locomotive would be back in service the autumn of 2022.

In August 2022 the locomotive passed an in-frames steam test and moved again under its own steam in the following month, before it was taken out of the hands of the 6024 Preservation Society, and moved to Crewe, where she remains with a totally unknown future.